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The composition of cryptophytes (geophytes) and other plants in the northern jarrah forest of Western Australia: An analysis of logged and old growth forest

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THE COMPOSITION OF CRYPTOPHYTES (GEOPHYTES) AND OTHER PLANTS IN THE NORTHERN JARRAH FOREST OF WESTERN AUSTRALIA: AN ANALYSIS OF LOGGED AND OLD GROWTH FOREST

By

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This thesis is submitted in partial fulfilment of the requirements for the completion of a degree of Bachelor of Science (Environmental Management) with Honours, at the School of Natural Sciences, Faculty of Computing, Health and Science, Edith Cowan University.

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ABSTRACT

Forests are decreasing globally and there are pressing requirements for ecologically sustainable forest management to be implemented at all scales. There has been some criticism of the public managers for forests and the processes used to select reserve systems and silvicultural methods used. Limited research has been conducted on the effects of logging on the plants of the northern Jarrah forest of south western Australia. While fire is a major disturbance event, disturbance during logging operations may remove non-commercial trees, understorey shrubs and change soil conditions. Some plants that regenerate from below ground storage organs such as Cryptophytes (Geophytes) may be affected by logging disturbance. Old growth forest by definition can be considered to be free of many of the disturbances found in logged forest, and offered a useful control for determining logging effects particular plant groups.

Research was carried out to determine under semi-controlled conditions, whether plants such as cryptophytes differed between logged and oldgrowth areas in the northern Jarrah forest. Field research was conducted at three separate areas in the northern Jarrah forest using paired one hectare sites of logged and oldgrowth forest each containing four replicate quadrats. Paired sites were selected that had minimal differences between variables of soil, landscape position, spatial separation and time since last fire. Temporal sampling was conducted for all vascular plants including Cryptophytes in particular. Site characteristics of stand structure and composition were also measured, along leaf litter depth and soil sampling. Soil samples were tested for a range of physico-chemical properties.

The results indicated that cryptophyte composition can differ between logged and oldgrowth areas. The logged areas tended to have fewer cryptophyte species and lower abundance. The mean number of trees, slope, the mean diameter of Jarrah trees and leaf litter were correlated with cryptophytes at some sites.

The conclusions were that logging disturbance at the studied areas of the Jarrah forest was very likely to be the factor for reduced cryptophyte abundance and that future management needs should consider a review of practices to limit impacts.

Declaration

I certify that this thesis does not incorporate without due acknowledgement any material previously submitted for a degree or diploma in any institution of higher education; and that to the best of my knowledge and belief it does not contain any material previously published or written by another person except where reference is made in the text.

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CHAPTER 1

1.0 INTRODUCTION

1.1 Background

In a world with decreasing forest area and an increasingly global marketplace, there are certainly pressing requirements for sustainable forest management to be implemented. While free markets may protect themselves, they may not protect the presence of healthy, functioning forest ecosystems into the future (Kerr 2001, Woodwell 2001). Some have argued that the general public has focused too much on the past, and too little on the present and future for forests (Franklin 2003). It has been suggested by Kimmins (1996) that with a continual increase in the world human population that society must move on from simply identifying problems in forests.

Forest resources are becoming less abundant and government legislation in Australia for the early 1990's acted to provide protection for public needs of ecological, social and economic sustainability. The Resource Assessment Commission (1992) recognised the need for multiple use forests and gave direction for achieving the three areas of sustainability. The expectations of the Western Australian public about forests management went beyond timber production

(primarily economic use) to include conservation of biodiversity, protection of water catchments (ecological use) and provision of areas for recreation, tourism and other uses (social use) (CALM 1992).

In Western Australia, the Conservation and Land Management (CALM) Act of 1984 had already recognised the need for multiple-use forests, going beyond the principle focus on timber harvesting of the previous century (Havel 1989a). The recognition of multiple uses was followed in 1985 by a major change in forest management for timber in Western Australia. Strategies were developed achieve objectives such as protecting CALM lands from environmental degradation from natural and exotic agencies, and human activities (CALM 1987).

In 1992, the Commonwealth of Australia released the National Forest Policy Statement (NFPS 1992), which set out processes for the assessment and agreement on a reservation system for forests. This system aimed for forest management to be comprehensive, adequate and representative (CAR system) and for timber harvesting to be conducted in an ecologically sustainable manner (NFPS 1992).

In 1998, the Regional Forest Agreement process (WARFA 1998) generated considerable public concern as the effective management and conservation of oldgrowth forest ecosystems was questioned. Scientific debate questioned the adequacy of the reserve system and credibility of the techniques and analysis used for RFA process for forest in Western Australia (McKenzie *et al.* 1996, Horwitz and Calver 1998).

1.2 Forest Management in Western Australia

The Department of Conservation and Land Management (DCLM) has been the manager of public forests in Western Australia since 1984, and the Forest

Products Commission (FPC) has assumed the role of managing timber production since the end of the year 2000. DCLM retained the responsibility for implementing ecologically sustainable development of the state's forests. A variety of material was published by scientists from the DCLM that challenged public perception of inadequate forest management and maintained that is was based on the application of principles for ecologically sustainable forest use, persistence of species and evolution (Abbott and Christensen 1994, 1995a, 1995b, 1996). The validity of these claims for ecologically sustainable forest use and whether they were being implemented was challenged by others in the field (Calver *et al.* 1995, Calver *et al.* 1998, Horwitz and Calver 1998). Similar issues had arisen for the RFA process in other parts of Australia (Lindenmayer and Recher 1998). The forest issues moved beyond the RFA process to the broader topic of ecologically sustainable forest management (ESFM).

1.3 The Jarrah Forest

In south western Western Australia, there are two main closed canopy forest types. These two types are the jarrah (*Eucalyptus marginata*) forest and the karri (*Eucalyptus diversicolor*) forest. The Jarrah forest is generally divided into two parts: the northern Jarrah forest that is dominated by this species, and the southern jarrah forest that intergrades with karri and other forest tree species. The northern jarrah forest was also further described by ecosystem type in the Comprehensive Regional Assessment (CRA) of WARFA (1998). The CRA divided the northern Jarrah forest into sections of jarrah northwest and jarrah northeast. These terms have not been used to any real extent in recent publications, so 'northern Jarrah forest' will continue to be used from this point on.

1.4 The Distribution of the Northern Jarrah Forest

The Jarrah (*Eucalyptus marginata*) forest is located in the south west of Western Australia. Jarrah most clearly dominates the northern part of this forest type based on height, as opposed to the southern part that has a mixed canopy with other eucalypt species and particularly marri (*Corymbia calophylla*) (Dell and Havel 1989). Marri is common in the northern jarrah forest, but exists as a sub-dominant tree species. The northern jarrah forest has a distribution that forms a north-south band largely concentrated along Darling Range. Specifically, jarrah forest is found over a large area that includes uplands and slopes with pisolitic laterite soils of varying fertility (Churchward and Dimmock 1989).

The boundaries of the northern jarrah forest have been described as the Avon River to the north, variously as the Preston River (near Waroona) or Blackwood River to the south (CALM 1987, Dell and Havel 1989). The northern jarrah forest has the Darling Escarpment/Swan Coastal Plain as the western boundary, and the lower rainfall areas with wandoo (*Eucalyptus wandoo*) woodlands of the agricultural zone as the eastern boundary. The eastern boundary of the higher quality jarrah forest also tends to be characterised by the presence of the shrub species *Adenanthos barbigerus* and *Grevillea wilsonii* (Havel 1975, Abbott and Loneragan 1986). The principle range of this forest type is from Gingin north of Perth extending southwards to Collie (Dell and Havel 1989). Recent estimates by the DCLM have stated a total area of managed public jarrah forest of approximately 1.1 million hectares (WARFA 1998).

1.5 The Plants of the Jarrah Forest

The Jarrah forest has the largest area of all forest types in Western Australia, and also holds a high level of plant species diversity relative to other forest types in the State. The northern jarrah forest tends to include a middle storey of small sub-

dominant trees of bull banksia (*Banksia grandis*), forest sheoak (*Allocasuarina fraseriana*), with a patchy distribution of snottygobble (*Persoonia longifolia*) and *Persoonia elliptica*) and parrot bush (*Dryandra sessilis*) (Havel 1989b). The understorey tends to be diverse, including plants from Families such as Cyperaceae, Dilleniaceae, Epacridaceae, Fabaceae, Mimosaceae, Myrtaceae, Proteaceae, Restionaceae and others.

1.6 Oldgrowth and Logged Forest

The capacity to sustain the integrity of oldgrowth forest areas is challenged by the effects of logging. To maintain forest integrity usually means to keep it in a near perfect state or within a normal range of conditions (Kimmins 1996). Logging can change the range of conditions for diversity and complexity in forest areas, which raises issues for off-reserve management of biodiversity conservation in these areas (Norton 1996, Lindenmayer and Franklin 1997b).

There have been numerous discussions on the relative merits of reserving areas of forests from logging. Reserving oldgrowth forests from logging has been an issue of environmental debate and clear definitions of this type of forest have been few (Hunter and White 1997). A workshop on oldgrowth forest in Australia (Dyne [ed] 1992) suggested that oldgrowth forest might be:

> An area of natural forest:
>
> 1. showing relatively few signs of direct disturbance by human activity;
> 2. with, in its upper storey, many specimens of trees which:
>   (a) are overmature or senescent,
>   (b) appear to be in the upper limits for the expected longevity of the trees for their site and species, and
>   (c) carry frequent crown and stem hollows as roosting sites for birds, bats and arboreal mammals; and
> 3. with stems of dead trees standing or present on the forest floor.

ESFM could allow many of these ecological features of oldgrowth forest to be retained in logged forest. Part of this project was to question whether ESFM is being achieved in jarrah forest, and how it relates to plants.

1.7 Jarrah Forest Silviculture

There have been a number of techniques used over the past century used to tend Jarrah forest for the requirement of producing tree crops and a consistent supply of harvestable timber.

The silviculture practices for jarrah forest over this period was described by Stoneman *et al.* (1989 p.336) as generally falling into five categories:

- Largely uncontrolled exploitation until the early 1920's.
- Group selection and intensive regeneration treatment from the early 1920's to early 1940's.
- Relatively light uniform selection cutting from mid 1940's to mid 1960's.
- Heavy selection cutting from mid 1960's to 1985, and
- Group selection and thinning from 1985.

The heavy selection silviculture technique in jarrah forest presented a medium to long-term sample group that could be used for testing for the effects of timber harvesting from this technique. While heavy selection cutting as a universal silvicultural technique for the Jarrah forest ceased in 1985, it is still represented as part of current jarrah forest silviculture. Jarrah forest silviculture now includes three types of prescriptions: gap creation (also known as group selection or release regeneration), thinning (growth promotion for retained trees) and shelterwood (establishing regeneration from seed). Heavy selection cutting would be most similar to the current practice of gap creation.

1.8 The Effects of Logging on Plants

There have been a limited number of published papers on the effects of logging on the understorey flora in native *Eucalyptus* forests in Australia (Cremer

and Mount 1965, Hickey 1994, Ough and Murphy 1996, Murphy and Ough 1997, Burrows *et al.* 2002). Four of the five publications deal with eastern Australian forests. Burrows *et al.* (2002) is the only publication that deals with Western Australian forest and covers the short-term effects of post-1985 jarrah forest silviculture on understorey plants.

Burrows *et al.* (2002) found that the potential for significant differences of plant species richness between at logged jarrah forest and coupe buffers four years after the disturbance differed within the three spatial scales used. The Burrows *et al.* (2002) study found that plant species richness was higher in adjacent coupe buffers than in shelterwood cut and gap cut jarrah forest (with statistical significance) at a 1 m^2 scale but not at a 30 m^2 or 150 m^2 scales. However, that study also found that plant abundance, irrespective of species, was higher in the adjacent buffers than in the logging coupes for both the shelterwood and gap cut forest. In particular relevance to this study, Burrows *et al.* (2002) found that logging coupes compared to adjacent buffers had proportionally fewer plant species from a guild that regenerates from fleshy storage organs below ground.

1.9 Disturbances Other Than Logging

Fire, non-commercial tree culling and reduction of understorey competition are disturbances that create effects that are external to those of commercial timber extraction (major overstorey change) from forests (Christensen and Kimber 1975; Shea *et al.* 1979; Bell 1980; Fox and Fox 1986; Christensen and Abbott 1989). Fire in particular can change understorey plant communities. Unpublished research by the author has suggested that disturbance created by some jarrah forest silvicultural practices resulted in reduction of understorey species richness, but it was not significantly linked to logging per se (the removal of trees), but rather to post-logging fire.

A Ph.D. study (nearing completion) by Alexander Watson at Edith Cowan University has shown particular groups of regenerating plant species appear to be negatively affected by the logging disturbance. This previous research had limited power due to restricted sample size and a focus on species richness and cover data rather than abundance of individual species. The previous work highlighted the need to conduct further research less affected by variables other than logging, but rather focussed on plant abundance as a primary measure. Adopting these points may assist in determining whether there are deleterious effects of logging that had previously not been detected for plant species of the northern jarrah forest.

1.10 Plant Life Forms

Plants can be placed into classes based on their life form (or size and location of regenerating buds) (Raunkiaer 1934). Some plant life forms have below ground storage organs that allow them to survive unfavourable conditions and regenerate afterwards. These plants often include hemicryptophytes and cryptophytes that can perennate from buds close to or below the soil surface respectively. Hemicryptophytes are usually herbaceous perennial plants that often have a basal rosette of leaves. Cryptophytes include aquatic and terrestrial plants. Terrestrial cryptophytes are more specifically known as geophytes. Geophytes often die back to below the soil surface (ground level) during the unfavourable season(s) of the year (Raunkiaer 1934).

Pate and Dixon (1982) outline how many Western Australian plant species have below ground storage organs that are represented in non-cryptophyte (geophytes) plant life forms using Raunkiaer's descriptions. This study has focussed on terrestrial cryptophytes (geophytes) and hemicryptophytes. Cryptophytes typically grow as herbaceous perennials that regenerate from organs such as bulbs, corms, root tubers, stem tubers and rhizomes. In the Jarrah forest, the majority of cryptophytes regenerate from below ground tubers, and for example these include plants from the Asteraceae (daisy family), Droseraceae (sundews), Orchidaceae (terrestrial orchids) and Anthericaceae (native lilies). Plants species like *Haemodorum* (Haemodoraceae) regenerate from bulbs.

1.11 How Fire Disturbance affects Jarrah Forest Plants

The effect of fire on the Jarrah forest flora is significant. Research by Christensen and Kimber (1975), showed that fire stimulated resprouting of nearly 70% of northern Jarrah forest species, with the remainder mostly being reseeding leguminous 'fire weeds'. The plant species diversity tends to peak after 3 – 5 years after fire in the northern Jarrah forest, with a decline occurring 5 –7 years after fire (Shea *et al.* 1979; Bell and Koch 1980). The germination of seeding species can often be high following intense fire (Bell *et al.* 1987; Christensen and Abbott 1989). The abundance of some herbaceous plant species is positively affected by frequent fire and have obligate dependence, but many plants that regenerate from fleshy storage organs (such as geophytic plants like orchids) tend to decrease with increases in fire frequency (Bell and Koch 1980, Fox and Fox 1986, Bell *et al.* 1987, Bell *et al* 1989, Christensen and Abbott 1989, Bell *et al.* 1993, Burrows and Wardell-Johnson 2003). The response to fire by these types of regenerators can vary. One study showed an increased density of orchids following fire in rehabilitated bauxite mines in jarrah forest areas (Grant and Koch 2003). While fire can affect the composition of plants, regenerating plants may still differ in the absence of recent fire. This group of plants may be a useful indicator of any differences between logged and oldgrowth forest for reasons outlined below.

There has been a range of reasons suggested for different densities of these geophytic regenerating species in Western Australian vegetation. The range of reasons for germination and persistence of orchid geophytes includes various interrelated soil factors such as: levels of leaf litter/potassium, potassium/clay presence, clay/moisture holding capacity, moisture holding capacity/leaf litter, leaf litter/organic matter in soil, organic matter/soil fungi and soil fungi/orchid symbiosis (Garrett 1956, Batty *et al.* 2001, Grant and Koch 2003).

Increases in densities of terrestrial orchids can be interrelated to factors mentioned above, but specifically to the presence of ectomycorrhizal fungi, relative freedom from competition and post-fire release of nutrients (Grant and Koch 2003). Mycorrhizal relationships can occur with reasonable specificity between fungal endophytes particular geophytes such as orchids (Warcup 1981). The presence of specific fungal endophytes can be dependant on presence of available soil organic matter (Garrett 1956).

The amount of soil organic matter is a product of the rate of input (accession or deposition) and the rate of decomposition or decay (loss) (Attiwill and Weston 2001). The removal of overstorey and disturbance of middle and understorey vegetation during timber harvesting operations is likely to influence the amount of soil organic matter. The amount of soil organic matter may be reduced as loss of vegetation may lead to deposition rates that are lower than those for losses.

The decay of litter and soil organic matter may speed up with increased soil temperatures due to increased light penetration of forest areas in overstorey gaps. The increase in soil temperature may also reduce available soil moisture due to increased evaporation rates. Decreased soil organic matter and moisture content can reduce the availability of nutrients from a lower cation exchange capacity in jarrah forests (Wallace and Hatch 1952). As many fungal endophytes reply on available soil moisture and organic matter, the germination and abundance of cryptophytes dependant on these fungi may in turn be low.

This research considered oldgrowth forest as a representative of natural forest undisturbed by logging. It is acknowledged that the limited number of areas of jarrah forest in this condition may have corresponding effects on the results of this research.

1.12 Objective

Cryptophytes are taxa that are potentially sensitive to changes of environmental conditions in the northern Jarrah forest. This project provided an opportunity to conduct research on the management issues of vascular plant communities in the northern jarrah forest of south western Australia.

Specifically, a focus was given to determining the effects of logging on the plants regenerating from fleshy storage organs (such as cryptophytes) and how this related to other biological and environmental characteristics in a semi-controlled research design.

The aim of this project was to ascertain whether cryptophytes were sensitive to changes in northern jarrah forest environments due to logging harvesting. This was achieved by addressing the following specific aims:

i. To determine whether differences exist in cryptophyte species abundance and richness in logged and oldgrowth jarrah forest.

ii. To determine how cryptophyte communities relate to the wider vascular flora in logged and oldgrowth jarrah forest.

iii. To determine what influence forest structure, soil and litter conditions have on cryptophytes in logged and oldgrowth jarrah forest.

iv. To review past management of plants in jarrah forest, and formulate recommendations for future management.

CHAPTER 2

2.0 METHODS

2.1 Introduction

This study focussed on the northern jarrah forest of Western Australia. The northern jarrah forest was selected for this research as it is clearly dominated by one species, has been extensively cut-over, has higher productivity, the catchments have largely fresh flowing water and conflicting land use issues are numerous (CALM 1987c, Dell and Havel 1989). These features do not typify the southern jarrah forest. The study area lies within the South-West Botanical Province and Darling Botanical District. The predominant vegetation can be broadly described as open forest of jarrah (*Eucalyptus marginata*) and marri (*Corymbia calophylla*).

2.1.1 Timescale

The issues of jarrah forest management relating to timber harvesting can be broadly categorised into short-term (zero-15 years following harvesting), medium-term (15-30 years after harvesting) and longer-term (>30 years after harvesting). Some research has suggested limited short-term effects on the species richness in the northern jarrah forest flora following timber harvesting (Burrows *et al.* 2002, Slee and Watson, in prep.). The latter study focussed on the medium-term effects of timber harvesting on jarrah forest flora, which may indicate a direction for long-term effects. Areas were established that were harvested during a fifteen-year period, 18 years prior to this research. The period of timber harvesting for the selected areas was 1970 to 1985. This was chosen, as forest management data (such as logging

details/records) were only available for a period of a decade prior to 1980, and yearly after that point. A period of fifteen years provided sufficient potential research areas to undertake the study. A period of less than ten years would not have yielded adequate numbers of candidate areas to effectively undertake the research. In addition to the range of years offered, between the years of 1970 and 1985, the primary silviculture technique used in the northern jarrah forest was heavy selection cutting (also known as gap logging). Having a similar silvicultural technique offered an opportunity to compare forest areas subjected to timber harvesting with unlogged areas with similar variability expected.

2.2 Site Variability

The effects of site variability required that the harvested and unharvested sites were arranged as paired samples. Variability due to soil type, aspect, landscape position and other environmental factors were controlled for by setting up paired samples for each treatment at adjacent locations. Visual inspection and map data were used to confirm no history of fire in the sampled areas during the eight years prior to the research (i.e. last fire occurred prior to Summer 1994/95). This limited the chance of variability due to fire, and increased the likelihood that any observed impact was due to timber harvesting. The logging types of interest were that of heavy selection cutting and also shelterwood cutting, which were the main practices from 1975 to 1985.

2.3 Areas

The areas covered in this project included a range of conditions across the distribution of the northern jarrah forest. The areas were selected with assistance

from the Forest Management Branch of the Western Australia Department of Conservation and Land Management (DCLM).

2.3.1 Geographic Information System Mapping

The Forest Management Branch has a detailed Geographic Information System (GIS) that includes data of jarrah forest timber harvesting history, silvicultural prescriptions, location of watercourses and tracks, and other useful details. These GIS data were used to generate maps showing DCLM managed lands, areas subjected to timber harvesting in the 1970's and 1980-1984/85, and areas unburned in the eight years prior to this research (i.e. prior to 1994/95). The reason for selecting the timber harvesting period of 1970 – 1985 was that this offered an opportunity to look for any differences in geophyte species and plants in general as they relate to timber harvesting on a medium-term scale.

2.3.2 Fire History

As jarrah forest is ideally prescribed burned on a seven to ten year rotation, sites nine or more years since last fire are very limited. Therefore, a period of greater than eight years since the fire exposure was selected for all sites due to availability. In addition, fire has a significant effect on understorey plants of the jarrah forest, and that the effects of this are displayed in the plant communities for 5-6 years after the event.

2.3.3 Timber Harvesting History

The timber harvesting period was selected based on these GIS data, which were only available at a decade level prior to 1980, and therefore 1970-1979 logged areas were represented as one unit colour on the maps produced. As the timber harvesting operations are often conducted during the drier months such as summer, the records often show a two-year period (e.g. 1984/85). The 1980/81 records through to those for 1984/85 timber harvesting were all represented as one colour on the maps for this five year period.

2.3.4 Ground Truthing

Ground truthing was done to check the accuracy of the map data, particularly for distribution of jarrah forest and fire history. Many potential candidate areas were eliminated due to being exposed to large, hot wildfires at the end of February 2003. The distribution of jarrah forest was not entirely accurate, as some areas marked on the map as being in this category were actually wandoo (*Eucalyptus wandoo*) woodland.

2.3.5 Area Selection

There were three areas chosen, and these related to: suitability for paired treatment sampling; appropriate fire history; ease of access; representativeness of latitude, longitude and rainfall gradients, and; proximity to the University as a travel/time consideration. The requirements for having areas that contained both harvested and unlogged jarrah forest in adjacent locations with a similar fire history was a major limiting factor for area selection. The time demands of travel during the course of this research also limited the capacity for having a large number of sample areas. The need for a high sampling intensity to be maintained also placed a limitation on the number of research areas that could be used.

2.3.6 Coverage

The areas covered a representative part of northern jarrah forest that included: western section and northernmost (moist); and eastern border further south (dry), and; central section and southern portions (wet) (see Figure 2.1). The western/northernmost jarrah forest area was located just north of Canning Reservoir east of Armadale, south of Brookton Highway, and about 35 kilometres SE of Perth City. The eastern border jarrah forest area was located along Edison Mill Road, north of Brookton Highway, about 85 kilometres ESE of Perth City. The central/southernmost area was located east of Harvey, south of the Worsley Alumina Mine Conveyor and Harvey-Quindanning Road, and around 135 kilometres SSE of Perth City.

2.3.7 Silvicultural Prescription

Although heavy selection cutting was the main silviculture technique used in the period identified in this study two silvicultural techniques appeared to have been used across the three areas. The logged Edison Mill Road and Harvey/Conveyor sites showed stem coppice regrowth with limited ground coppice confirming that heavy selection cutting was the silviculture technique used in those areas. The logged Canning Dam site showed only limited stem coppice, but considerable ground coppice and young seedling growth, that suggested some of the forest was regenerating from a shelterwood silviculture technique.

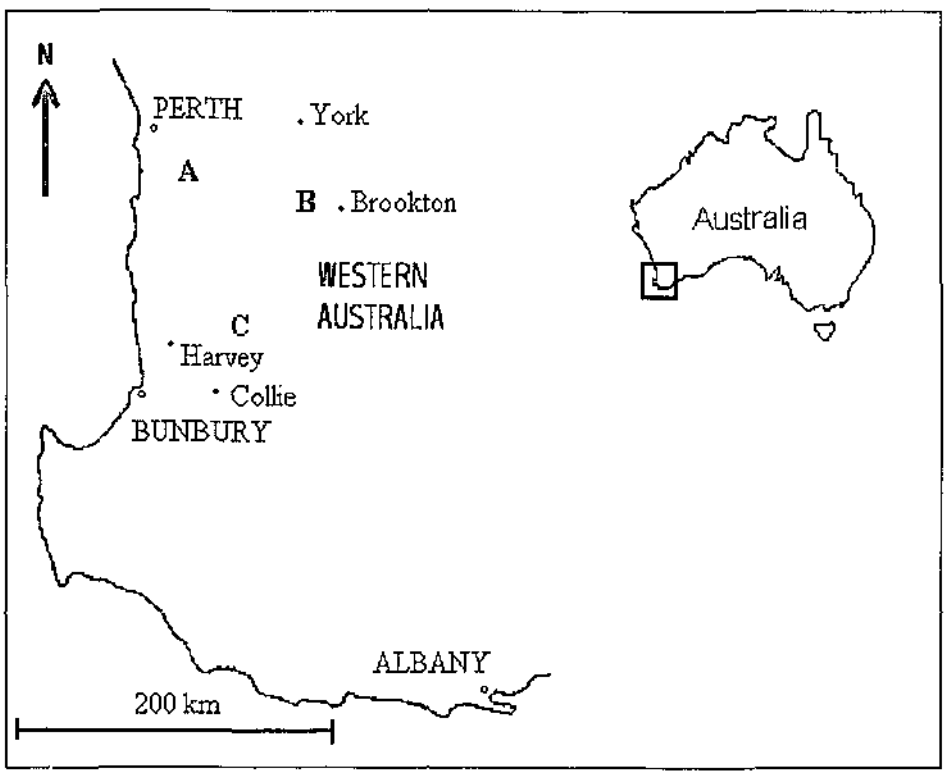

Figure 2.1 The location of the three study areas in the south west of Western Australia. A: Area near Canning Dam; B: Area in eastern forest near Brookton; and, C: southern central Jarrah forest east of Harvey and near Worsley Alumina Conveyor.

2.4 Sites

The location of sites was arranged to meet the pairwise criterion. This required the selection and establishment of paired sites that were close to each other and had similar environmental conditions other than history of timber harvesting. This was done to reduce the likelihood that any observed differences could be due to irregularities in the local environment, rather than timber harvesting disturbance. Adjacent areas were identified of unharvested forest areas and areas subjected to harvesting operations between 1970 and 1984/85. Those areas that had not been exposed to fire in the previous eight years (since 1994/95) were surveyed to confirm that similar environmental conditions were present in the harvested and unharvested areas. Environmental conditions were checked for: relative position on the slope, similar slope and aspect and similar soil type. Adjacent harvested and unharvested sites selected were no more than 200 metres apart, and met these pairwise criteria (Figure 2.2).

2.4.1 Canning Dam Sites

The harvested site north of Canning Dam was harvested using a shelterwood silviculture technique. The shelterwood technique retains several large seed bearing trees to promote regeneration when ground coppice is absent or limited. The unharvested site had several large logs on the ground, which were greater than one metre in diameter. The understorey vegetation was dominated by soap bush (*Trymalium floribundum*) and *Clematis pubescens*.

2.4.2 Edison Mill Road Sites

As these sites were located on the eastern margins of the northern jarrah forest region, they were found on upper slope/hilltop areas, with wandoo (*Eucalyptus wandoo*) woodland found nearby on lower slopes. This area had two pairs of sites, as required for the within-area variability testing.

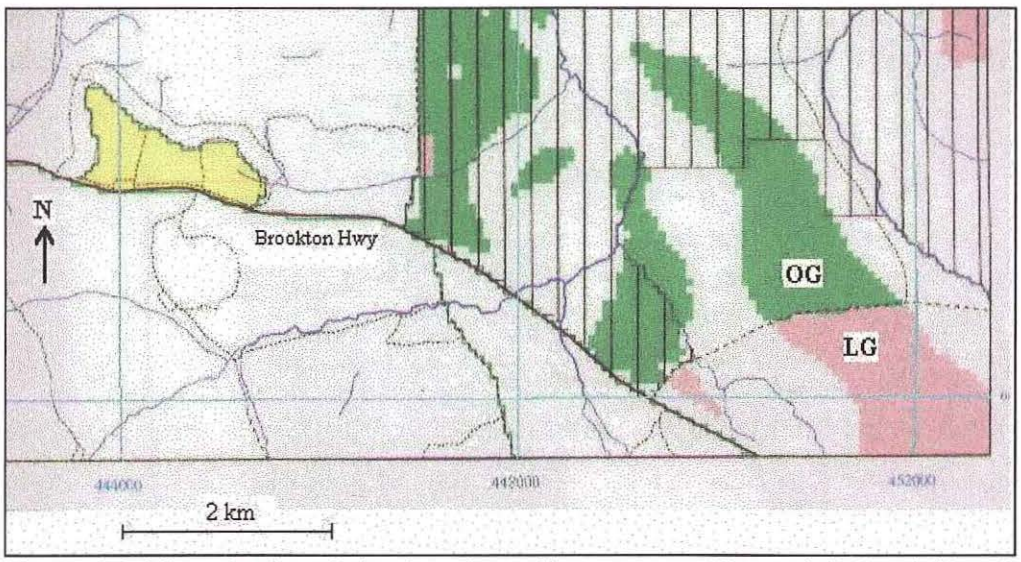

Figure 2.2 The selection of sites based on adjacent areas of Logged (LG - pink) and Oldgrowth (OG - green) jarrah forest. This example shows the areas north and south of Edison Mill Road about two kilometres north east of the intersection with Brookton Highway (FMB 2003).

The logged sites had limited obstruction from trees and shrubs with a visibility over 100 metres possible into each site. The harvested jarrah trees, as evidenced by cut stumps, were widely regenerating by stem coppice growth. Many of the stumps with stem coppice had more than five stems arising from the base. Coarse woody debris was mostly contained in piles away from trees at the harvested sites. The unharvested sites were characterised by the presence of a near complete understorey cover, with thickets of *Dryandra carduacea*. Fewer trees were present with a larger range of sizes compared to the harvested sites.

2.4.3 Harvey/Conveyor Sites

These were located approximately three kilometres south of Harvey-Quindanning Road (east of the two conveyor belt passes), and about two kilometres west of the Bibbulmun Track. The harvested and unharvested sites had typical growth of trees (i.e. stem coppice and large/old respectively). The pair of sites was approximately 200 metres apart, with the harvested (logged) site having a lower position and gradient on the slope compared to the unharvested (oldgrowth). The unharvested site had many leguminous species and also an abundance of large decaying logs on the ground. The harvested site had several piles of coarse woody debris (CWD – also known as residue or trash) present.

2.5 Site Marking

There were four pairs of sites (four oldgrowth and four logged), with two of the pairs arranged closely to get an indication of within history (treatment) variability at an area level. Each site was one square hectare in size, with four replicate quadrats at random distances from the centre of the site (to reduce clustering problems). The centre of each site was located by marking the intersection of the

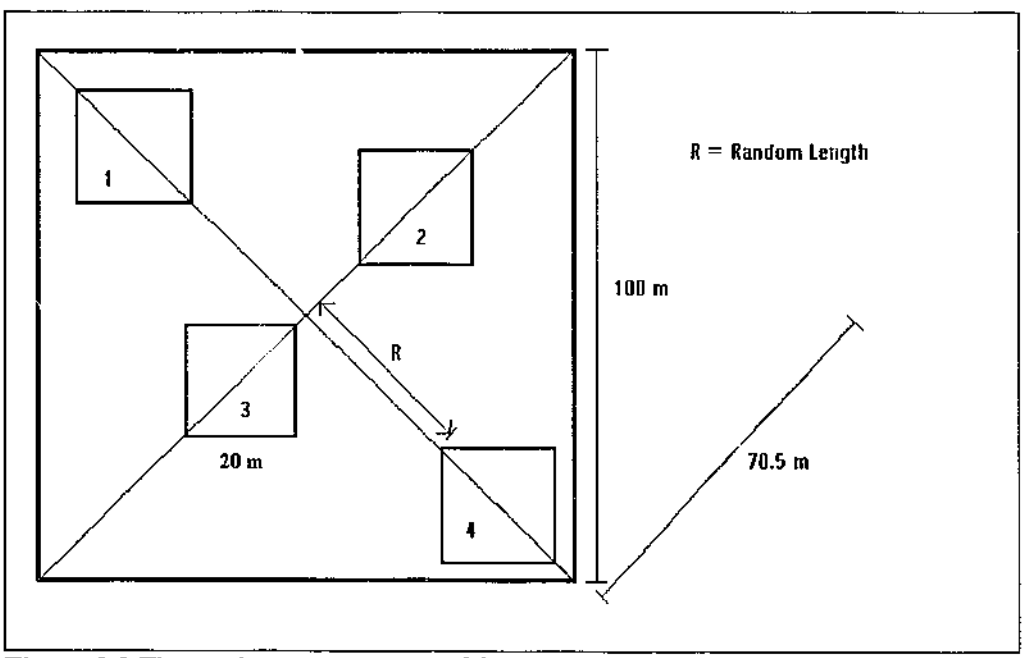

Figure 2.3 The random arrangement of four 20 x 20 metre plots at a site level.

required distance (70.5 metres) from adjacent corners. Each quadrat replicate (random plot) was 20 x 20 metres (400 m^2), with a stake to mark each corner (Figures 2.3 & 2.4). These 20 x 20 metre replicates were demarcated with a fibreglass tape connecting the corner stakes during data collection. This tape marking was done to facilitate sampling, and generally improve the ease of knowing what was 'in' and what was 'out'.

Figure 2.4. Marking out a plot in a logged site at Edison Mill Road.

2.6 Data Collection

2.6.1 Flora

The sampling of vascular flora was done under licence of DCLM for research purposes. Data were only collected on the understorey flora (<2.5m high). The flora variables sampled for were: presence/absence (species richness) and the percentage

cover for all understorey plant species. Abundance data was collected for all cryptophyte species sampled.

2.6.1.1 Temporal sampling

Temporal sampling for species richness at all sites was conducted through July to October 2003 to allow adequate opportunities to observe all plant species present. Woody perennial shrubs were sampled in July and August, while geophytes, other perennial herbs and annuals were sampled in September and October (the key flowering and emergence time for these taxa). The variables were chosen to provide measures in addition to species richness that may assist in representing differences in the vascular flora between harvested and unharvested areas that may pose issues for biodiversity conservation.

2.6.1.2 Flora Variables

The percentage cover and composition data were generated for woody perennial shrubs for each 20 x 20 m replicate plot. Percentage cover was measured on an ordinal scale of 0 – 5 (**0**: Not present; **1**: < 1% cover; **2**: 1 – 5% cover; **3**: 5 – 25% cover; **4**: 25 – 50% cover; **5**: 50 – 100% cover).

2.6.1.3 Cryptophyte sampling

The cryptophyte sampling included plants that perennate from buds below the soil surface (geophytes) and those from buds at or near ground level (hemicryptophytes). All plants in these groups were generally referred to as cryptophytes. Cryptophytes were counted using a stratified search technique (Figure 2.5). This was because abundance data offered a more useful comparison between sites than percentage cover.

The stratified search technique used for sampling geophytes involved walking at a slow pace through the plot, starting at a corner marker and then proceeding along parallel to one side of the plot about 1.5 metres from the edge and conducting a visual sweep sample around 1.5 metres either side of the selected path (a three metre wide band). Each 20 metre sweep was followed by the next three metres wide band of vegetation adjacent to the last sweep, until the entire plot had been completed. It usually took seven sweeps to sample each plot.

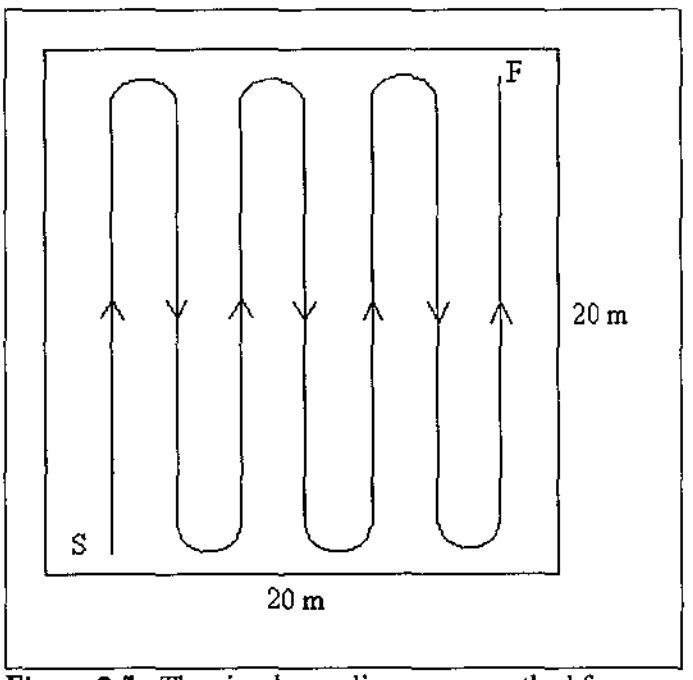

Figure 2.5. The visual sampling sweep method from Start (S) to Finish (F) for cryptophyte counts in each 20 m x 20 m plot.

2.6.1.4 Vouchers and Determination

Three voucher specimens were taken where possible of each species, to provide for identification, herbarium collection and personal records. Specimens are to be lodged at the WA Reference Herbarium and the herbarium for the School of Natural Sciences at Edith Cowan University, Joondalup.

2.6.2 Environmental Characteristics

2.6.2.1 Soil

Soil samples were collected from each plot between the months of August and October 2003, and subsequently treated and tested.

2.6.2.1.1 Soil collection, storage and separation

Soil samples were comprised of a bulked sample of the A-horizon (top 5cm) from four random locations within each 20 x 20 m quadrat, of 300 and 500 grams. Soil samples were stored, dried and sieved according to Ohlinger (1995a,b). Soil samples were air dried for one week at room temperature (~25 °C) and further oven dried at 40 °C for 48 hours. The soil was passed through a two millimetre sieve to separate the larger gravel/root fraction from the smaller soil fraction. The mass was recorded for each fraction. Gravel was then excluded from subsequent analysis.

2.6.2.1.2 Soil testing

Soil samples from each plot of 250 grams were tested at the CSBP Soil Analysis Laboratories (Wesfarmers CSBP Ltd.). CSBP Laboratory testing on the soil samples included: texture, colour, macronutrient content (nitrogen as nitrate, nitrogen as ammonium, phosphate, potassium), sulphur, organic carbon, iron, electrical conductivity, pH using calcium chloride solution and pH using water.

Texture of the non-gravel fraction was determined using the hand texture approach to assess the degree to which a moist soil bolus held together. An ordinal scale was used for soil texture: 1 = sand; 1.5 = sand/loam; 2.0 = loam; 2.5 = loam/clay; 3.0 = clay, 3.5 = heavy clay, 4 = very heavy clay. Sub-samples were used to prepare 1:5 soil-water extracts and appropriate electrodes were then inserted within the extracts to measure water pH, electrical conductivity and nitrate-nitrogen (with aluminium sulphate solution). Two measures of pH were taken using water solution and an estimation following extraction in 0.01mol L^{-1} calcium chloride (also 1:5 ratio).

Ammonium-nitrogen was extracted in 1 mol L^{-1} potassium chloride solution then measured colorimetrically using indo-phenol blue reaction (Rayment and Higginson 1992). Available phosphorus and potassium were both extracted from soil samples using sodium hydrogen carbonate solution. The concentration of phosphate was then measured colorimetrically, and the phosphorus levels determined using (flame) atomic absorption spectrophotometry (Colwell 1965, Rayment and Higginson 1992).

Reactive iron indicates the extent to which phosphorus is immobilised in the soil, and was measured by atomic absorption after extracting the soil with Tamm's reagent (ammonium oxalate-oxalic acid solution). Organic carbon was determined colorimetrically in comparison to glucose standards following oxidation of the soil in chromic acid (Walkley and Black 1934).

2.6.2.2 Litter

The depth of coarse organic litter was measured at four random locations in each plot that corresponded (paired with) the locations for the bulked soil samples. The measurements for soil coarse litter were made vertically down to where the fraction was less than 5mm in size. Litter depth was recorded to the nearest five millimetres and a mean value given for each plot.

2.6.2.3 Slope

The slope of each plot was measured to the nearest 0.5° incline (if a slope was present). Slope measurements were made using an Abney Level Clinometer towards a marked or flagged tree at 1.8 metres (eye level) high (Husch *et al.* 1982). Aspect and slope measurements were recorded by obtaining an upslope bearing (reverse aspect) using a compass. Upslope measurements (rather than down slope) were done to maintain consistency in the measuring technique and also to produce positive values (for analysis).

2.6.2.4 Forest Structure

The forest structure of each site was established by measuring individual tree and stand characteristics to obtain diameter at breast height over bark (DBH) and basal area (BA) of trees. The stand structure varied with the presence of different tree and tall shrub species. All single stemmed plants greater than 2.5 metres high forming part of the middle storey or overstorey were measured for circumference at 1.5 metres above the ground. Each circumference measurement also included the species from which it was taken. Circumference was measured in metres, with accuracy of two decimal places. These circumference data were transformed into DBH. These structure measurements were taken from all trees present within each plot.

The 'plotless' method was used for forest structure to gauge basal area. Measurements of 'plotless' forest structure data were made using 360° horizontal sweeps of an angle gauge (normally referred to as a basal area prism (BA prism)) with a scaling basal area factor (BAF) of one, plus a dendrometer with a scaling factor of one (Ek *et al.* 2003). The particular devices used for the structure measurements were an angle gauge CM2M Cruise-Master Prism (Sublimity, Oregon) BA prism, and a Dendrometer II (Prospectors Earth Sciences). The BA prism included data for all tree images not refracted past the true image, and every second borderline tree (Husch *et al.* 1982). The Dendrometer II measurements included all data from trees larger than the factor one tooth, and every second borderline tree.

The structural measurement sweeps were made and recorded from the centre of each plot (which were randomly positioned). The BA Prism can be prone to variable results so the data produced were verified against the dendrometer measurements. The dendrometer was comparatively easy to use, with data mostly uniform during repetition. These structural measurement approaches were used as they suited rapid assessment in the field.

2.7 Analysis

Data were entered in Microsoft Excel spreadsheets then imported into the statistical packages of SPSS V.11 and PRIMER 5 for Windows. Where required, assumption testing was conducted for within-site comparisons of variability, homogeneity of variance and homoscedacity. Testing of similarity of variance was done between paired sites. The within-site differences in the means of single variables were conducted using t-tests. Size class distributions were used to compare within and between site variability of forest stand structure.

Between-site comparisons were done with SPSS using paired-samples t-tests for single variables. Multivariate comparison between sites were conducted using ordination and clustering to compare within-site variation to between-site variation. Ordinations and classifications within 2-dimensional space were done using PRIMER software (see Carr 1997, Clark and Warwick 1994). These provided a visual demonstration of whether harvested and unharvested sites differed when controlled for fire and environmental characteristics. Site by species matrices were converted to dissimilarity matrices (site by site, or between treatment), which showed any patterns that occurred with environmental variables in ordination space.

Similarity matrices were formed to generate lists of species similarity percentages (SIMPER), with data on dissimilarity percentages, expressed as species percent contribution to the difference. As plant species percentage cover data were recorded using an ordinal scale, no transformation was required. The count data for geophytes required a $Log_{10}(V+1)$ transformation in similarity matrices to allow for equality in weighting of species contributions relative to the magnitude of each count. Similarity matrices were ordinated using Multi-Dimensional Scaling (MDS). These MDS were represented in 2-dimensions.

Multivariate data such as species composition and environmental variables were tested using ANOSIM, MANOVA and BIOENV, recognising techniques used in Kent and Coker (1992). Comparisons between areas were obtained using mean values for the replicates at each site and treating these mean values as samples.

CHAPTER 3

3.0 RESULTS

3.1 Plant community differences between sites

Overall there were 186 plant species recorded across the three areas studied. Of these, 43 were considered to be cryptophyte or low hemicryptophyte life forms. All cryptophytes and low hemicryptophytes were considered together and called 'cryptophytes' for simplicity, as the distinction was not always clear in the field. There was a total of 11096 cryptophyte plants counted during this research. The cryptophyte group did include several small hemicryptophyte species that had rosette leaf arrangements. The main characteristic of all the plants surveyed in the 'cryptophyte' searches was the presence of fleshy below ground storage organs that potentially allowed for persistence through dry months and regeneration.

There were three weed species surveyed in the cryptophyte group that included: *Hypochaeris glabra, Myrsiphyllum asparagoides* and *Oxalis corniculata.* The non-cryptophyte weed species *Conyza bonariensis* was also encountered at a few sites and included in the general survey of all plants. There were 184 plant species sampled in total across all areas.

3.2 Differences In Cryptophytes Between Areas And Site Pairs

A MDS of all cryptophytes counts across all sites showed that while there was some clustering based on area, the logged and oldgrowth sites tended to be distinct (Figure 3.1). Indeed, even with the two pairs of sites at Edison Mill Road,

both oldgrowth sites were closely clustered in ordination space. The oldgrowth sites of Edison Mill Road therefore showed a high level of similarity with each other despite the fact that each was geographically closer to its respective paired logged site. Curiously, each of the logged sites at Edison Mill Road was less clustered within-site, and also within-treatment relative to the oldgrowth sites. The Edison Mill Road logged sites were less similar in ordination space than the oldgrowth sites.

With the exception of the Harvey/Conveyor site pair, all other oldgrowth sites showed more similarity clustering than corresponding logged site within each pair. An interesting spatial arrangement occurred with the areas. Despite being little more than 30 kilometres apart, the Edison Mill Road and Canning Dam areas were less similar than the Canning and Harvey/Conveyor areas. A distance of around 100 kilometres separated the Canning and Harvey/Conveyor sites.

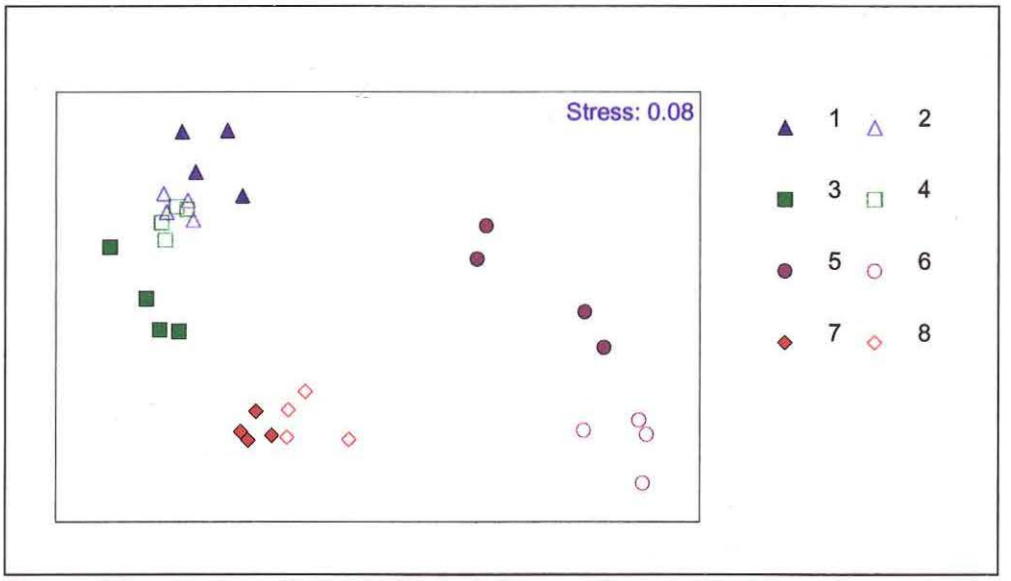

Figure 3.1 A transformed MDS of the cryptophyte counts and composition from all plots at all sites. Closed symbols represent logged sites, open represent oldgrowth sites. Triangles represent Edison Mill Road first pair plots, Squares – Edison Mill Road second site pair plots, Circles – Canning Dam plots, Diamonds – Harvey/Conveyor plots. Number index: 1 – LGEDSN1; 2 – OGEDSN1; 3 – LGEDSN2; 4 – OGEDSN2; 5 – LGCANN1; 6 – OGCANN1; 7 – LGCONV1, and; 8 – OGCONV1.

There was a similar level of spatial difference within the Canning Dam area as was found between the Edison Mill Road and Harvey/Conveyor areas. Both the Harvey/Conveyor and Edison Mill Road areas showed a similar level of clustering between logged and oldgrowth sites. There was a considerable difference (i.e. limited clustering) in cryptophyte counts/composition between the Canning logged and oldgrowth sites.

A cluster analysis of transformed cryptophyte abundance showed the similarity percentages between each plot quadrat, site, pair and area for cryptophytes (Figure 3.2). The cluster showed that the main separations based on similarity occurred firstly between areas, then between sites, and finally between plots.

The cluster analysis showed that there was a separation at about 15% similarity between the sites from the Canning area from the Conveyor (Harvey) and Edison Mill Road areas. The Conveyor and Edison Mill Road areas separated at about a 30% similarity level. At about a 60% similarity level, the logged and oldgrowth sites from Edison Mill Road were separated. The Edison Mill Road oldgrowth sites were separated at about 80% similarity, and plots at about 85%. The oldgrowth plots at Edison Mill Road showed the smallest range (<10%) in percentage separation of clusters based on similarity.

The two logged sites at Edison Mill Road separated at about 50% similarity, with varying separation points for plots between around 70 – 85%. Curiously, one of the plots from the second logged site at Edison Mill Road was well separated from all other plots in the logging history, and placed intermediate between logged and oldgrowth sites for this area.

The Conveyor plots separated between logged and oldgrowth sites at about 55% similarity with the exception of one plot from the latter site. One of the oldgrowth plots was clustered with the logged plots and separated at around 70 % similarity. The Conveyor logged plots separated in the cluster at intervals between

80 – 90% similarity. The Conveyor logged plots had the two plots from all areas that separated at the highest level of similarity level compared to all others.

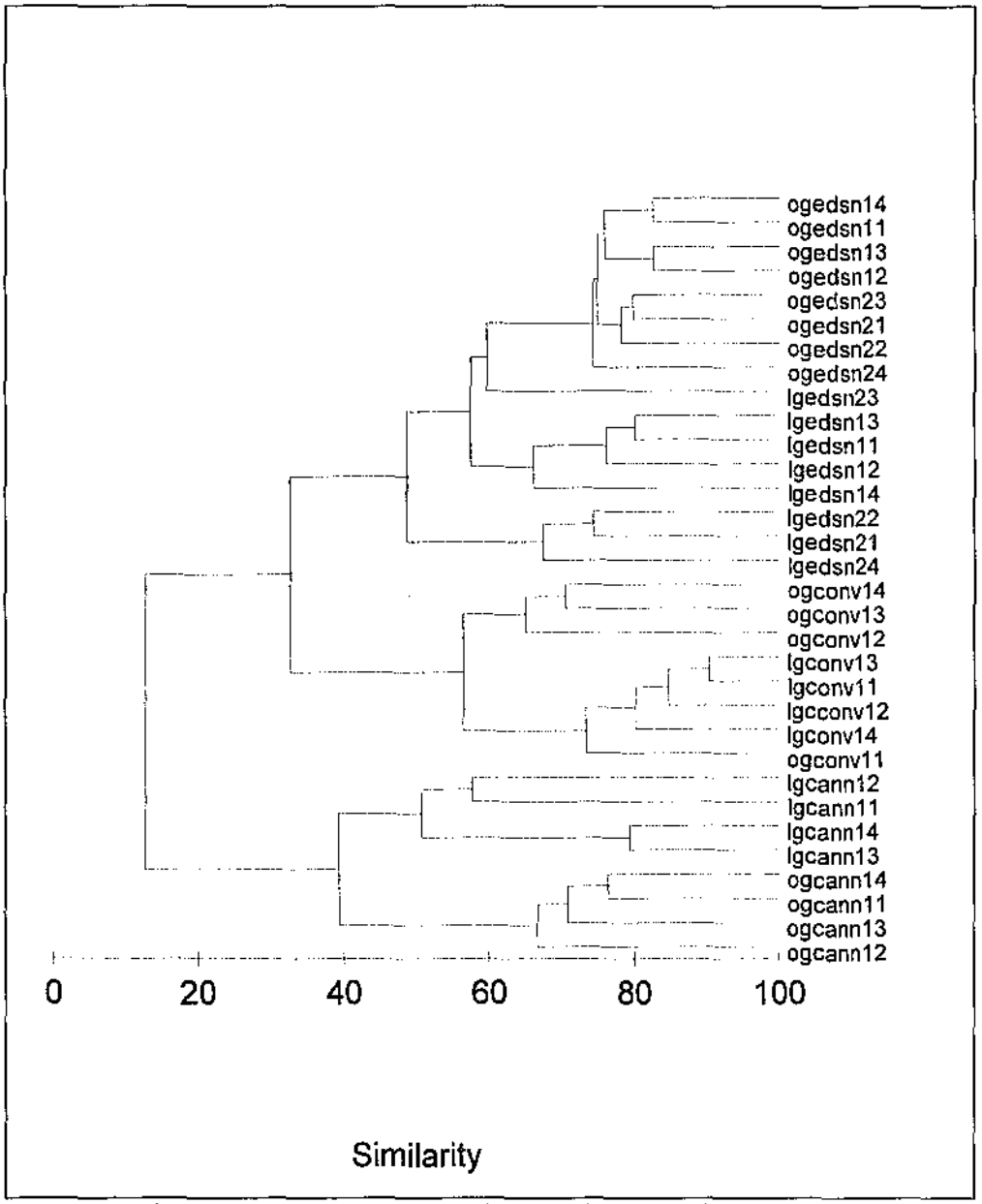

Figure 3.2 Cluster analysis of transformed cryptophyte abundance between all plots/quadrats and all sites.

3.3 Differences In Cryptophytes Within Each Site Pair

3.3.1 Clustering of Logged and Oldgrowth Plots at Edison Mill Road Pair 1

The similarity of cryptophyte abundances separated at 60% between the first pair of sites at Edison Mill Road (Figure 3.3). The plots for the first logged site at Edison Mill Road were separated by a range of similarities between about 65 – 80%. The oldgrowth plots for this pair showed separation of two-plot pairs firstly at a 75%, and secondly at a roughly 82% level.

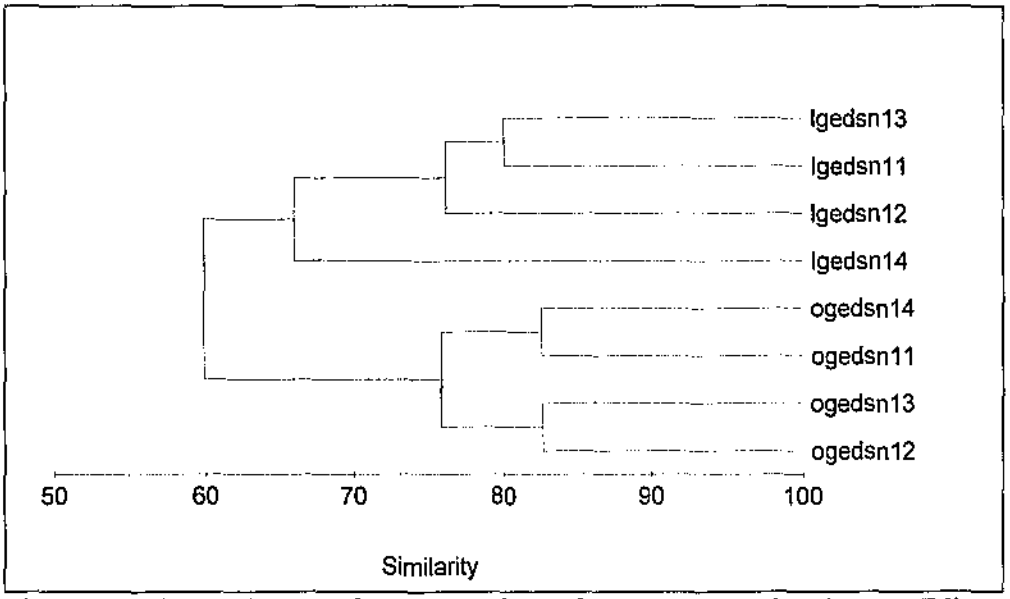

Figure 3.3 Cluster diagram of transformed data for cryptophyte abundance at Edison Mill Road Pair 1.

3.3.2 Clustering of Logged and Oldgrowth Plots at Edison Mill Road Pair 2

The second pair of sites at Edison Mill Road firstly separated at about 55% between three logged plots and the oldgrowth site with remaining logged plot (Figure 3.4). The three clustered logged plots had similarity levels of about 68 – 75%. The remaining logged plot (lgedsn23) shared similarity with the oldgrowth plots to a level of 60 %. The oldgrowth plots separated in a staggered way between about 74 – 80% similarity.

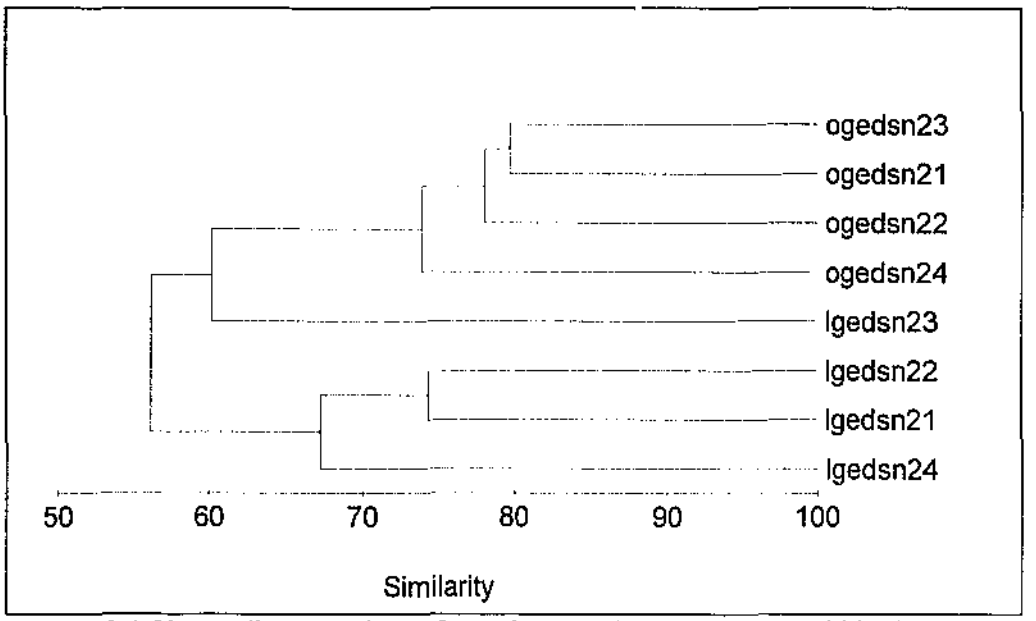

Figure 3.4 Cluster diagram of transformed cryptophyte abundance within the Edison Mill Road Site pair 2.

3.3.3 Clustering of Logged and Oldgrowth Plots at the Canning Area

With the Canning pair of sites, there was a relatively low level of similarity (40%) between the cryptophyte abundances in each of the forest histories (Figure 3.5). The limited similarity between the sites was paralleled in the logged site, but not so for the oldgrowth site. There was a range of 50 – 80% similarity between plots at the logged site and around 68 – 78% similarity for the oldgrowth plots.

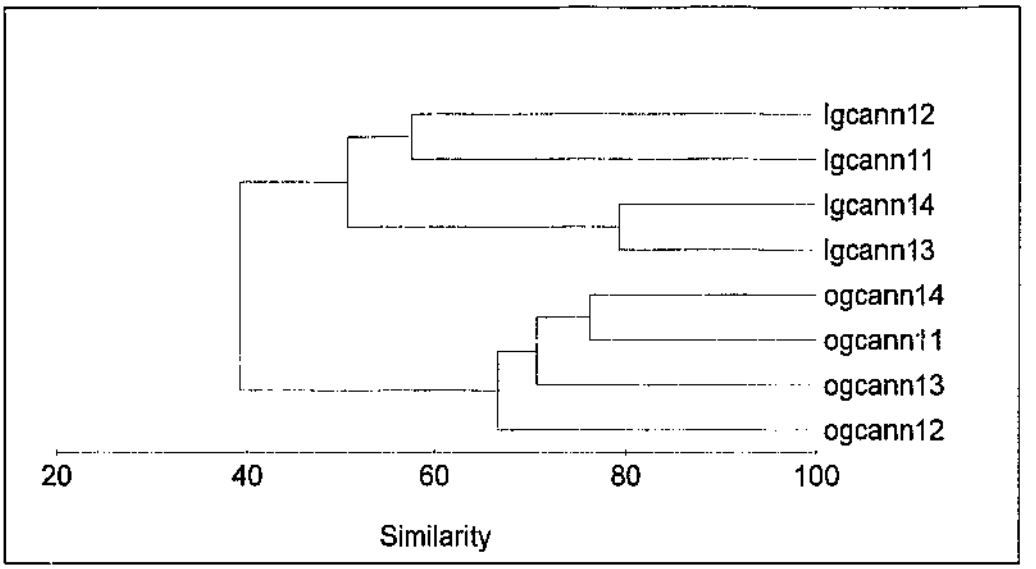

Figure 3.5 Cluster analysis of transformed cryptophyte abundance within the Canning site pair.

3.3.4 Clustering of Logged and Oldgrowth Plots at the Conveyor Area

The Conveyor (Harvey) and did not show a comparable level of similarity as other areas between logged and oldgrowth sites and within-site plots (Figure 3.6). Indeed, the oldgrowth site showed less similarity between plots (range ~ 56 – 72%) than the plots from the logged site (range 80 – 90%).

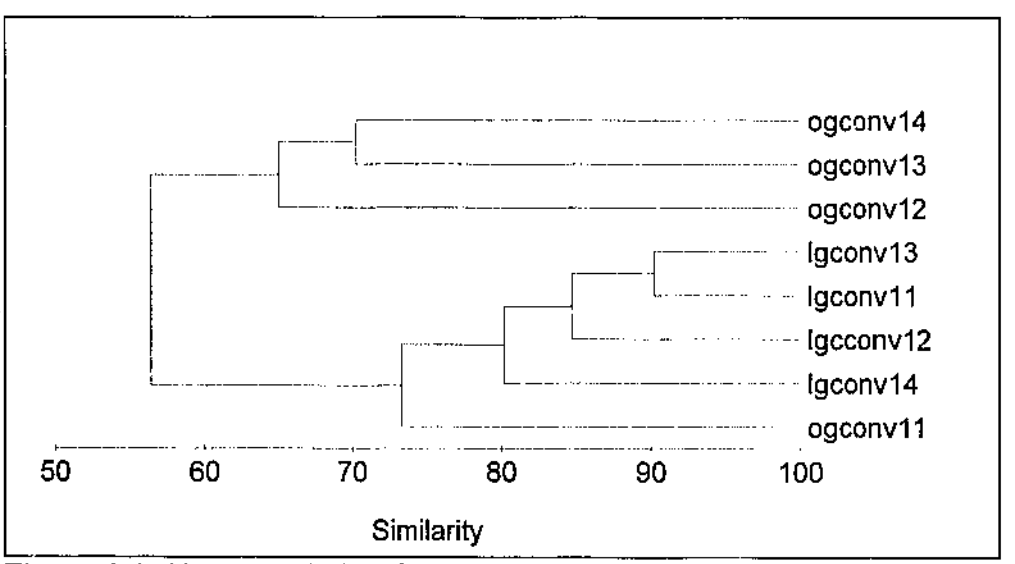

Figure 3.6 Cluster analysis of transformed cryptophyte abundance within the Conveyor (Harvey) site pair.

3.4 Cryptophyte Analysis Of Similarity

A Global Test was performed to generate ANOSIM results. ANOSIM had a sample statistic Global R value of 0.898, with high significance of P = 0.001. The significant difference applied between all sites using the log transformed cryptophyte abundance data, with the only exception of the oldgrowth sites at Edison Mill Road. The oldgrowth sites at Edison Mill Road were shown not to be different using the global test. The differences within the site pairs is given particular further attention for two separate reasons. These reasons are that within site pair comparisons are the main focus of this study and distance is likely to have been a major contributor to the differences observed between sites at different areas.

3.4.0 Similarity Percentages Of Cryptophytes

SIMPER analyses were conducted on transformed data of cryptophyte abundance. In particular, a similarity matrix was produced that formed the basis of within-site similarity percentages and within-pair dissimilarity percentages for abundance of particular cryptophyte species. A matrix of the dissimilarity percentages between all sites has been provided (Table 3.1). There were significant dissimilarities between all of the sites with the exception of both of the oldgrowth sites from Edison Mill Road. The focus here will remain on the cryptophyte flora composition and abundance, and the differences of similarity percentages for individual species for the established between site pairs. The average abundance (AA) and dissimilarity contribution percentage (DC) have been used to compare sites.

Table 3.1 Dissimilarity percentages of cryptophyte abundance. A matrix showing the dissimilarity percentages between all sites using log transformed data of cryptophyte abundance.

Site	Lgedsn1	Ogedsn1	Lgedsn2	Ogedsn2	Lgcann1	Ogcann1	Lgconv1
Ogconv1	74.91	67.52	63.73	69.09	74.55	80.12	40.00
Lgconv1	67.93	69.94	57.88	67.96	77.90	85.96	
Ogcann1	96.83	97.82	96.49	97.89	60.74		
Lgcann1	84.18	84.93	86.55	84.04			
Ogedsn2	43.32	25.27	43.22				
Lgedsn2	58.58	48.01					
Ogedsn1	40.12						

3.4.1 Differences Between Cryptophytes for the First Pair of Sites at Edison Mill Road

The untransformed dissimilarity percentages from the first pair of sites from Edison Mill Road showed that of the five cryptophyte species contributing up to 50% of the dissimilarity, that three were more abundant in the logged site and two were more abundant at the oldgrowth site (Table 3.6). The Warty hammer orchid (*Drakaea gracilis*) contributed the most to the dissimilarity (15%) and was close to four times more abundant in the oldgrowth site than the logged site. The triggerplant *Stylidium brunonianum* and mulla mulla species *Ptilotus manglesii* contributed around 14 % and 9 % respectively to the dissimilarity between the sites, and were more abundant (61 % and 44 % respectively) in the logged site compared to the oldgrowth site. *Stylidium amoenum* contributed 7.5 % to the dissimilarity and had a mean abundance of 38 plants per plot at the oldgrowth site, which was more than ten times higher than the logged site. *Drosera stolonifera* had around 7 % contribution to the dissimilarity, with an average 36 plants per plot at the logged site, and one per plot at the oldgrowth site.

Table 3.2 The Dissimilarity of Pair 1 sites at Edison Mill Road
The dissimilarity percentages of cryptophyte species average abundance between the first pair of logged and oldgrowth sites at Edison Mill Road. The average abundance represented is of actual counts. The percentage contribution and cumulative percentage contribution of each species has been shown.

Species	Av. Abund LGEDSN1	Av. Abund OGEDSN1	Contrib. %	Cum. %
Drakaea ?gracilis	23.75	87.75	15.47	15.47
Stylidium brunonianum	105.50	65.50	13.95	29.42
Ptilotus manglesii	94.75	65.75	8.85	38.26
Stylidium amoenum	4.00	38.25	7.57	45.83
Drosera stolonifera	36.25	1.34	6.73	52.57

The transformed cryptophyte data for the first pair of sites at Edison Mill Road shared the weighting of the contribution percentages of each species to the overall dissimilarity. Eight cryptophyte species contributed a cumulative percentage of 50% to the dissimilarity, with a further six species taking it to 75 % (Table 3.3). Unlike the results of the untransformed data, *Drakaea ?gracilis* was ranked five rather than first in the contribution to dissimilarity based on percentage, and was

Table 3.3 Dissimilarity of transformed data for Site Pair 1 at Edison Mill Road
The dissimilarity percentages for transformed cryptophyte average abundance/counts between the first pair of sites at Edison Mill Road. The percentage contributed individually and cumulatively to the dissimilarity by each of the 14 listed species has been shown.

Species	Av. Abund. LGEDSN1	Av. Abund. OGEDSN1	Contrib. %	Cum.%
Drosera scorpioides	0.00	2.94	8.30	8.30
Drosera stolonifera	3.31	0.62	7.68	15.98
Pyrochis nigricans	2.50	0.00	7.06	23.04
Caladenia flava	0.00	2.30	6.55	29.60
Drakaea ?gracilis	2.35	3.01	6.46	36.05
Stylidium junceum	0.35	2.57	6.32	42.37
Stylidium amoenum	1.02	2.18	6.18	48.55
Thelymitra crinita	0.00	1.93	5.44	53.99
Eriochilus dilatatus	0.40	2.17	5.15	59.14
Drosera erythrorhiza	2.15	3.50	4.30	63.44
Caladenia reptans	1.12	2.45	4.03	67.48
Haemodorum sp. 1	2.73	3.73	3.80	71.28
Trichocline spathulata	1.51	0.45	3.58	74.86
Pterostylis ?nana	0.40	1.34	3.34	78.19

replaced in this position by *Drosera scorpioides*. The contribution rank of the first four species in this analysis was: *Drosera scorpioides* (8.3 %), *Drosera stolonifera*(7.7 %), *Pyrochis nigricans* (7.1 %) and *Caladenia flava* (6.6 %). The following four species (ranked 5 to 8) were arranged: *D.?gracilis* (6.5 %), *Stylidium junceum* (6.3 %), *Stylidium amoenum* (6.2 %) and *Thelymitra crinita* (5.4 %). The final six species *Eriochilus dilatatus*, *Drosera erythrorhiza*, *Caladenia reptans*, *Haemodorum sp. 1*, *Trichocline spathulata* and *Pterostylis ?nana* individually contributed between 5.2 % and 3.3% to the dissimilarity. Eleven of the fourteen cryptophyte species shown on the table were had a higher abundance in the oldgrowth site compared to the logged site.

3.4.2 Dissimilarity Between Cryptophytes of the Second Pair of Sites at Edison Mill Road

The second pair of sites for Edison Mill Road showed six cryptophytic species that contributed up to 50 % to the cumulative dissimilarity (Table 3.4). The three sundews (*Drosera*) that were included in these six species contributing to dissimilarity were: *Drosera glanduligera* (rank 1, 17.8 %), *Drosera erythrorhiza* (2, 9.3 %) and *Drosera scorpioides* (5, 6.3 %). The dwarf pink fairy orchid (*Caladenia reptans*) was ranked third (contrib. 7.6%), followed by *Haemodorum sp. 1* (7.4 %), with the final place taken by *Stylidium junceum* (6.3 %). *D. glanduligera* and *D. scorpioides* were absent from the oldgrowth and logged sites respectively. *D. erythrorhiza* had an average abundance of 78 plants per plot at the oldgrowth site, three times higher than the corresponding logged site.

Table 3.4 The Dissimilarity of the Second Pair of Sites at Edison Mill Road
The dissimilarity percentages for cryptophyte average abundance/counts between the second pair of sites at Edison Mill Road. The percentage that each species contributed individually and cumulatively with above listed species has been shown.

Species	Av. Abund. LGEDSN2	Av. Abund. OGEDSN2	Contrib. %	Cum.%
Drosera glanduligera	112.25	0.00	17.84	17.84
Drosera erythrorhiza	26.50	78.25	9.26	27.10
Caladenia reptans	6.50	50.25	7.63	34.73
Haemodorum sp. 1	16.00	45.50	7.43	42.16
Drosera scorpioides	0.00	38.00	6.31	48.47
Stylidium junceum	45.50	20.00	6.31	54.78

At Edison Mill Road, the transformed data for the second pair of sites showed 14 cryptophytic species that contributed to at least 75% of the dissimilarity between the logged and oldgrowth sites, with eight of these making up the first 50% (Table 3.5). *Drosera glanduligera* remained as the highest contributing species (9.1 %) to the dissimilarity between the second pair of sites in this analysis. However, *Drosera erythrorhiza* was less important in this analysis in relation to dissimilarity between sites, with slightly less than 3 % contribution. *Drosera scorpioides* was raised from fifth to second place with a DC of 8.5 %, and *Haemodorum sp. 1* from fourth to third with a DC of 6.9 %.

Stylidium amoenum, Drakaea ?gracilis, Stylidium ciliatum, Stylidium brunonianum and Patersonia babianoides were positioned four to eight in the list respectively with DC's between 6.2 % and 5.4 %, and were the remaining top 50% dissimilarity contributing cryptophytes. In a similar pattern with the first pair of sites at Edison Mill Road, *Caladenia reptans* and the white bunny orchid *Eriochilus dilatatus* both had DC's around 4 to 5 %. Contrastingly, the Red beak orchid

Pyrochis nigricans had a DC of 3.7 % (about half that in the first pair of sites) and in the opposite direction (higher AA in oldgrowth) to the previous pair.

Table 3.5 The dissimilarity of transformed data for Pair 2 at Edison Mill Road The dissimilarity percentages for transformed cryptophyte average abundance/counts between the second pair of logged and oldgrowth sites at Edison Mill Road. The percentage contributed individually and cumulatively to the dissimilarity by the 14 listed species has been shown.

Species	Av. Abund. LGEDSN2	Av. Abund. OGEDSN2	Contrib. %	Cum. %
Drosera glanduligera	3.69	0.00	9.11	9.11
Drosera scorpioides	0.00	3.38	8.48	17.59
Haemodorum sp. 1	1.21	3.53	6.92	24.51
Stylidium amoenum	1.38	3.74	6.15	30.66
Drakaea ?gracilis	1.18	2.41	6.08	36.74
Stylidium ciliatum	0.72	3.09	6.06	42.80
Stylidium brunonianum	0.52	2.54	5.65	48.45
Patersonia babianoides	0.00	2.08	5.36	53.81
Eriochilus dilatatus	0.49	2.24	4.66	58.47
Caladenia reptans	1.47	2.85	4.46	62.93
Trichocline spathulata	2.67	1.28	4.40	67.33
Pyrochis nigricans	0.00	1.52	3.68	71.01
Burchardia umbellata	1.61	0.45	3.51	74.52
Drosera erythrorhiza	3.19	4.35	2.96	77.48

Native gerbera *Trichocline spathulata* (DC 4.4%) was similar in being proportionally more abundant at the logged site, as was found in the first pair of sites. The milkmaids species *Burchardia umbellata* was thirteenth in the list of contribution (DC 3.5 %).

3.4.3 Dissimilarity Between Cryptophytes at the Canning Pair of Sites

There was only one species making up the first 50 % contribution to the dissimilarity of cryptophytes at the Canning logged and oldgrowth sites (Table 3.6). This species was *Clematis pubescens*, a sprawling vine-like plant that had an AA of 158 at oldgrowth plots, and a DC of 61%. This species was present only to a rare extent at the logged site.

Table 3.6 Dissimilarity of the Canning pair of sites
The dissimilarity percentages for cryptophyte average abundance/counts between the paired Canning sites. The percentage contribution to the dissimilarity between the sites by *Clematis pubescens* has been shown. As this species contributed more than 50% to the dissimilarity, no other species were shown.

Species	Av. Abund. LGCANN1	Av. Abund. OGCANN1	Contrib. %	Cum. %
Clematis pubescens	1.50	158.00	60.06	60.06

Eight species were identified as contributing up to 75 % cumulatively in the transformed cryptophyte data for the Canning logged and oldgrowth sites, of which four made up the first 50% contribution (Table 3.7). Of the eight species, five had higher AA values for the logged site. *Clematis pubescens* continued to be the main species contributing to the dissimilarity within the transformed data from the Canning sites. However, the DC of *C. pubescens* changed to 22.5%, with *Ranunculus colonorum* ranked second with a DC of 16.3 %. Several of the species could be considered to have life forms more associated with hemicryptophytes than cryptophytes, but were considered in the analysis due to very limited species available for comparison in the latter category. The exotic species *Oxalis corniculata* was relatively common at the Canning oldgrowth site and was placed third in the table with a DC of 16.3%. There were three cryptophytic triggerplant species found at the Canning area, of which the golden triggerplant *Stylidium*

ciliatum and the lovely triggerplant *Stylidium amoenum* were only found at the logged site (DC 8.2 % and 5.9 % respectively). The circus triggerplant *Stylidium bulbiferum* and *Burchardia umbellata* had also had higher AA values in the logged site with DC's of 7.3 % and 3.7 % respectively. A soft lush green grass-like plant was suggested to provide a DC of 4%, but this is questionable based on the similar AA values.

Table 3.7 Dissimilarity of the transformed data for the Canning sites.
The dissimilarity percentages for transformed cryptophyte average abundance/counts between the Canning logged and oldgrowth sites. The percentage contributed individually and cumulatively to the dissimilarity by eight listed species (including one exotic) has been shown. The exotic has been marked with '*'.

Species	Av. Abund. LGCANN1	Av. Abund. OGCANN1	Contrib. %	Cum. %
Clematis pubescens	0.62	5.07	22.53	22.53
Ranunculus colonorum	0.00	3.29	16.29	38.82
**Oxalis corniculata*	0.91	2.17	9.01	47.84
Stylidium ciliatum	1.65	0.00	8.24	56.08
Stylidium bulbiferum	1.81	1.69	7.27	63.35
Stylidium amoenum	1.20	0.00	5.91	69.25
Soft lush grass (unkn.)	0.69	0.83	4.05	73.30
Burchardia umbellata	1.31	0.69	3.73	77.04

3.4.4 The Dissimilarity Between Cryptophytes at the Conveyor pair of sites.

The logged site at the Conveyor (Harvey) area contained higher abundances of the two cryptophytic species contributing up to 50 % of the dissimilarity within the pair of sites (Table 3.8). *Craspedia variablis* is a rosette-forming native species from the Asteraceae family that showed weedy behaviour with an AA of 120 at the logged site, but only 18 at the oldgrowth site. The small, two to three leaved herb

Chamaescilla corymbosa had a similar AA score to the previous species and a DC of 23.4 %.

Table 3.8 Dissimilarity of the Conveyor (Harvey) Site Pair.
The dissimilarity percentages for cryptophyte average abundance/counts between the paired Conveyor (Harvey) sites. The percentage contributed individually and cumulatively to the dissimilarity by each of the two species listed has been shown.

Species	Av. Abund. LGCONV1	Av. Abund. OGCONV1	Contrib. %	Cum. %
Craspedia variablis	119.75	18.25	32.32	32.32
Chamaescilla corymbosa	119.00	58.00	23.35	55.68

Using the transformed data, five species were identified that contributed up to 50 % dissimilarity between the logged and oldgrowth Conveyor sites, with a further five species explaining the next 25 % dissimilarity (75 % overall). *Craspedia variablis* remained as the main species contributing to dissimilarity (DC 12.8 %) between the logged and oldgrowth sites. Five of the nine other species were more abundant in the Conveyor logged site than the oldgrowth site. These five species included *Trichocline spathulata*, *Burchardia umbellata*, two *Drosera* species and *Chamaescilla corymbosa*. All of the orchids in the list were more abundant at the oldgrowth site and had DC's of 7.2 – 5.0 %. Like the oldgrowth site at the Canning area, the exotic *Oxalis corniculata* contributed to the dissimilarity by being more abundant there (it was absent for the Conveyor logged site).

Table 3.9 Dissimilarity of the transformed data for the Conveyor sites. The dissimilarity percentages for transformed cryptophyte average abundance/counts between the Conveyor logged and oldgrowth sites. The percentage contributed individually and cumulatively to the dissimilarity by the ten listed species (including one exotic indicated by a '*') has been shown.

Species	Av. Abund. LGCONV1	Av. Abund. OGCONV1	Contrib. %	Cum. %
Craspedia variablis	4.79	2.27	12.85	12.85
Trichocline spathulata	2.94	0.62	11.71	24.55
Burchardia umbellata	2.55	0.66	10.17	34.72
Drosera stolonifera	1.79	0.00	8.95	43.67
Caladenia reptans	1.75	2.64	7.24	50.92
Caladenia flava	0.60	1.45	7.04	57.95
Drosera erythrorhiza	4.24	2.88	6.73	64.69
Thelymitra crinita	0.72	1.32	5.02	69.70
Chamaescilla corymbosa	4.54	4.05	4.70	74.40
**Oxalis corniculata*	0.00	0.83	4.14	78.54

3.5 Differences in All Plant Composition

3.5.1 Differences for All Plants at the First Pair of Sites at Edison Mill Road

There were five species that accounted for 14 % of the dissimilarity between the first logged and oldgrowth site pair for Edison Mill Road (Table 3.10). The species ranked in order or highest to lowest contribution were *Caladenia flava, Drosera scorpiodes, Allocasuarina humilis, Petrophile seminuda and Dryandra sessilis. D. sessilis* was the only species with a higher ranked percentage cover score.

Table 3.10 The dissimilarity percentages for five species from all the plants within

the Edison Mill Road first pair of sites. Average dissimilarity = 34.13

Species	LGEDSN1 Av.Abund	OGEDSN1 Av.Abund	Contrib%	Cum.%
Caladenia flava	0.25	3.00	3.14	3.14
Drosera scorpioides	0.00	2.50	2.91	6.05
Allocasuarina humilis	1.75	4.00	2.64	8.69
Petrophile seminuda	0.50	2.75	2.54	11.22
Dryandra sessilis	2.00	0.75	2.34	13.57

3.5.1 Differences for All Plants at the Second Pair of Sites at Edison Mill Road

There were five species contributing 13 % to the dissimilarity between the second pair of logged and oldgrowth sites at Edison Mill Road (Table 3.11). The species in order of highest to lowest contribution were *Dryandra carduacea, Drosera glanduligera, Drosera scorpiodes, Haemodorum sp. 1* and *Patersonia babianoides.* Of these five species, only *D. glanduligera* had a higher average cover score in the logged site.

3.5.1 Differences for All Plants for the Pair of Sites at Canning Area

There were six species contributing 20 % to the overall dissimilarity in plants between the logged and oldgrowth sites at the Canning areas (Table 3.12). The six species were ranked from highest to lowest as follows: *Hibbertia hypericoides, Ranunculus colonorum, Anagallis arvensis* (exotic), *Bossiaea ornata, Clematis pubescens* and *Pteridium esculentum.* The two species *H. hypericoides* and *B. ornata* found across much of the Jarrah forest were absent from the oldgrowth site and present at the logged site. The species *A. arvensis* was only found at the oldgrowth site.

Table 3.11 The dissimilarity percentages contributed by five plants species between the logged and oldgrowth sites at the second Edison Mill Road pair. Average dissimilarity = 39.27

Species	LGEDSN2 Av.Abund	OGEDSN2 Av.Abund	Contrib %	Cum. %
Dryandra carduacea	0.50	4.25	3.38	3.38
Drosera glanduligera	3.00	0.00	2.64	6.02
Drosera scorpioides	0.00	2.75	2.49	8.50
Haemodorum sp.1	1.25	3.75	2.38	10.89
Patersonia babianoides	0.00	2.50	2.24	13.13

Table 3.12 The dissimilarity percentages of six species together contributing 20 % to difference between the logged and oldgrowth sites at the Canning area.

Species	LGCANN Av.Abund	OGCANN Av.Abund	Contrib%	Cum.%
Hibbertia hypericoides	3.50	0.00	5.43	5.43
Ranunculus colonorum	0.00	2.25	3.52	8.94
**Anagallis arvensis*	0.00	2.25	3.52	12.46
Bossiaea ornata	2.25	0.00	3.51	15.98
Clematis pubescens	2.00	4.00	3.18	19.16
Pteridium esculentum	0.00	2.00	3.13	22.28

3.5.1 Differences for All Plants for the Pair of Sites at Conveyor (Harvey) area

There were six plant species contributing 20 % to the dissimilarity between the logged and oldgrowth forest at the Conveyor area (Table 3.13). These six species were ranked from highest to lowest in following order: *Trymalium ledifolium, Macrozamia riedlei, Phyllanthus calycinus, Caladenia flava, Acacia saligna* and

Lomandra sp. 1. All of the species with the exception of *Trymalium ledifolium* had higher average cover scores in the oldgrowth forest site.

Table 3.13 The dissimilarity percentages of six plants contributing the top 20% to the difference between the logged and oldgrowth sites at the Conveyor area. Average dissimilarity = 33.39

Species	LGCONV Av. Abund	OGCONV Av. Abund	Contrib. %	Cum. %
Trymalium ledifolium	2.75	0.25	4.42	4.42
Macrozamia riedlei	1.25	3.50	4.00	8.42
Phyllanthus calycinus	0.75	2.50	3.11	11.52
Caladenia flava	0.75	2.00	3.09	14.61
Acacia saligna	0.50	2.25	3.09	17.70
Lomandra sp. 1	0.00	1.50	2.65	20.35

3.6 Differences in Species Richness Between Sites

3.6.1 Mean Species Richness for All Plants

Two of the site pairs had higher mean species for all cryptophyte and non-cryptophyte plants at the oldgrowth site, while the remaining two pairs had higher scores for the logged sites (Figure 3.7). Both of the site pairs at Edison Mill Road had higher, but not significant, mean plant species richness at the oldgrowth sites. The Canning and Conveyor (Harvey) site pairs had higher mean plant species richness at the logged sites. The Canning site pair was the only one of the four that had a significant difference in mean species richness. The second pair of sites at Edison Mill Road had the highest overall species richness, followed by the second pair of sites at the same area, the Conveyor pair and Canning pair respectively.

3.6.2 Mean Species Richness for Cryptophytes

The cryptophyte mean species results were similar in magnitude but not significance as those for overall plants (Figure 3.8). The t-test results showed that

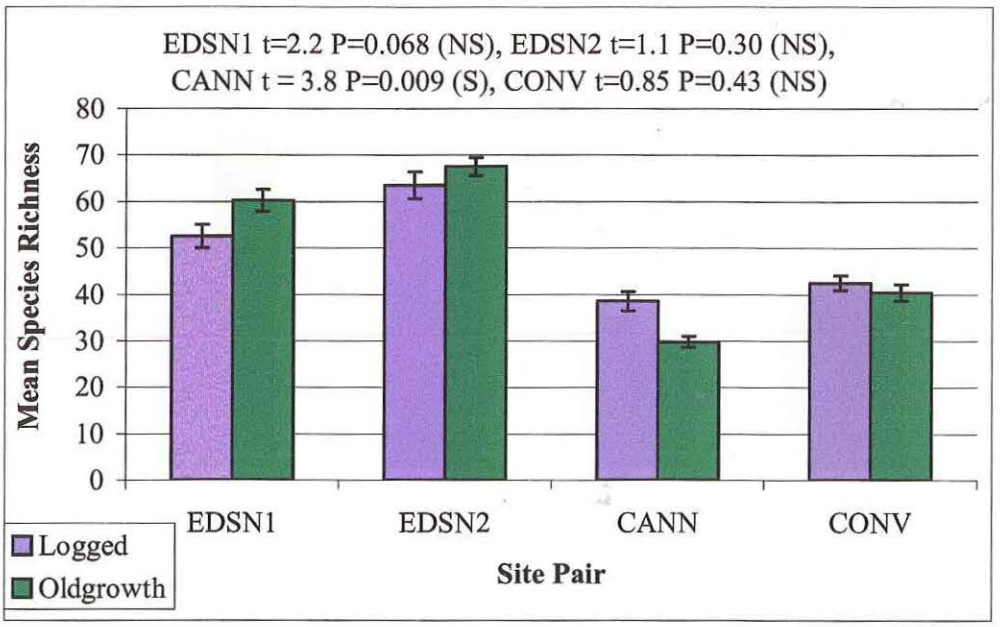

Figure 3.7 The mean plant species richness per plot (400 m^2) of all sites at all areas, showing +/- 1 SE. NS = Not Significant, S = Significant result.

there was a significant difference between the logged and oldgrowth. Both oldgrowth sites at Edison Mill Road were significantly higher in cryptophyte species richness than each of the logged sites with which they were paired. The second and first Edison Mill Road oldgrowth sites were followed in the same order by their paired logged sites, with respect to ranked species richness for cryptophytes.

The species richness for cryptophytes was respectively lower for the Conveyor and Canning areas. The Conveyor area did have higher species (not significant) richness for cryptophytes at the oldgrowth site. The logged Canning site had slightly higher cryptophyte species richness (not significant) than the oldgrowth site from the same area. The Canning and Conveyor areas had mean cryptophyte species richness scores that were about half of those for the Edison Mill Road area.

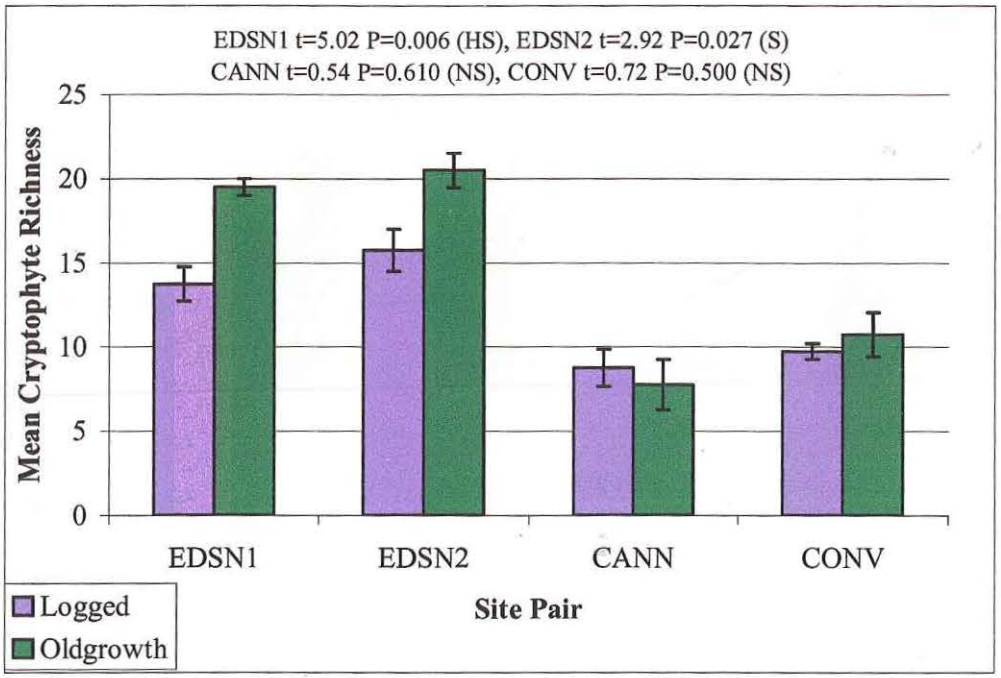

Figure 3.8 The mean species richness of cryptophyte plants for site pairs of each logged and oldgrowth site. Bars show +/- 1 SE. HS = Highly significant result, S = Significant, NS = Not significant.

3.7 Mean Cryptophyte Abundance

The mean abundance of all cryptophytes irrespective of species (mean of the total count) was significantly different between three of the four site pairs, and not significant for the remaining pair (Figure 3.9). The mean cryptophyte abundance for the 400 m^2 plots was highest for both of the oldgrowth sites (~560 plants) at Edison Mill Road, although only the first site was significantly different from the paired logged site. The sites within the pair at the Canning area were significantly different with the logged site having a mean cryptophyte abundance of 73 plants, which was 27 % of the abundance for the oldgrowth site (270). The situation was reversed for the Conveyor area, with the oldgrowth site having a mean cryptophyte abundance of 43 % of the figure obtained at the logged site from that pair.

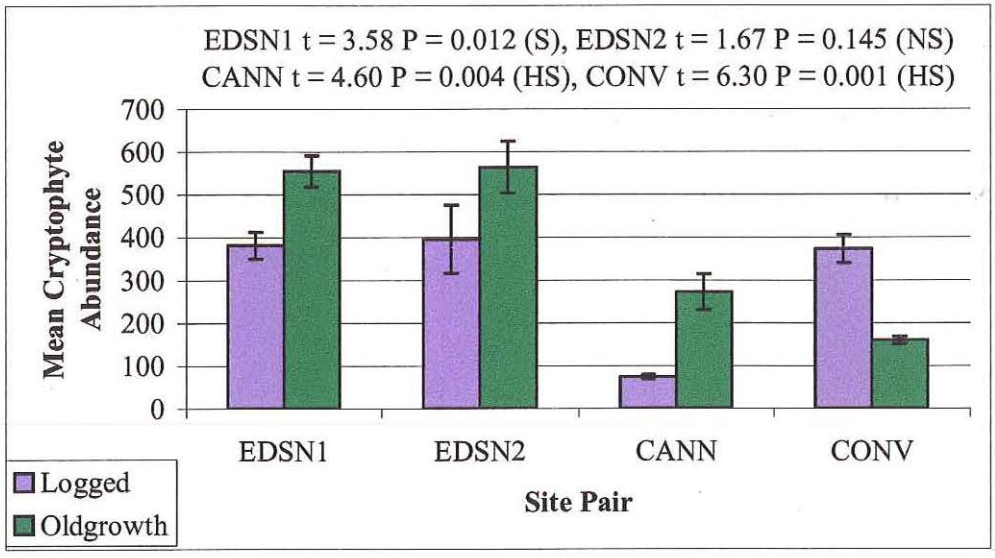

Figure 3.9 The mean cryptophyte abundance at all sites, showing bars for +/- 1 SE. HS = Highly significant result, S = Significant result, NS = Not significant.

3.8 Environmental Variables

The environmental variables were divided into the biological and general categories. The biological variables related to stand structure and soil litter, while the general variables related to slope, aspect and soil.

3.8.1 Stand Structure

There were six variables considered relating to stand structure. These variables were: the mean diameter of Jarrah trees, the number of Jarrah trees, the overall mean diameter of trees from all species, the mean number of trees from all species and the basal area scores for the prism/angle-gauge and the Dendrometer II.

3.8.1.1 Mean jarrah tree diameter

Two of the areas had site pairs with significant differences in the mean diameter of Jarrah (Figure 3.10). The significant difference occurred for the mean diameter of Jarrah trees between the sites in each pair from the Canning and within and between sites of the same pair. The results shown here are for each of the four plots for the logged and oldgrowth Conveyor sites. Conveyor areas. There was no significant difference for mean Jarrah diameter between each of the sites for each pairs at the Edison Mill Road area.

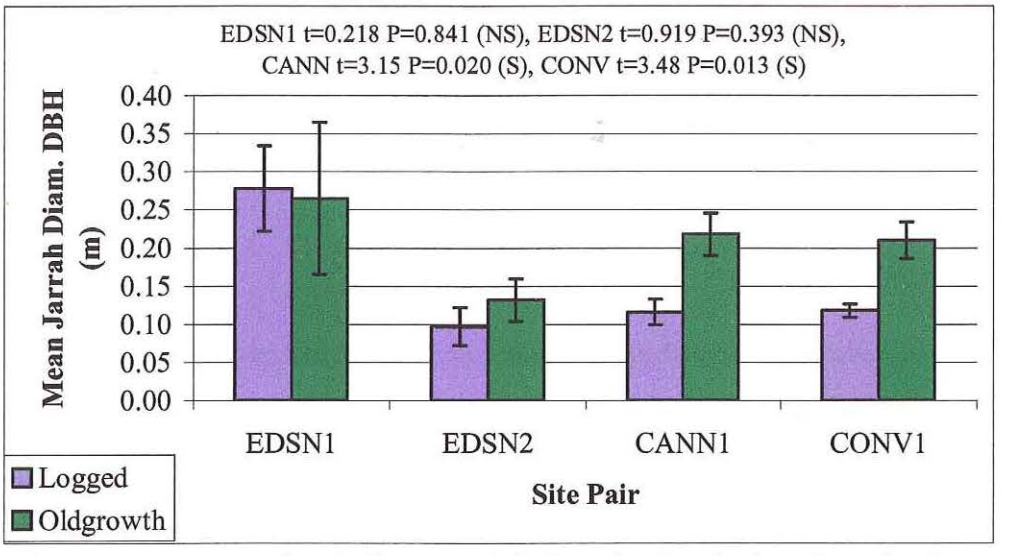

Figure 3.10. The mean jarrah diameter of all site pairs showing bars for +/- 1 SE. S = Significant result, NS = Not significant.

The differences between mean jarrah tree diameter at a plot level for each site has been represented with the example of the logged and oldgrowth plots for the Conveyor area (Figure 3.11). There is a higher level of standard error between the mean jarrah diameter scores for the plots of the oldgrowth site compared to the logged site of the Conveyor area. The overall variability of the mean jarrah tree diameter was higher in the oldgrowth forest site compared to the logged forest site. The oldgrowth site at the conveyor area had a range of about 0.11 of a metre between

mean jarrah tree diameters for plots. The logged site had a range less than half the magnitude of the oldgrowth site (0.04 m).

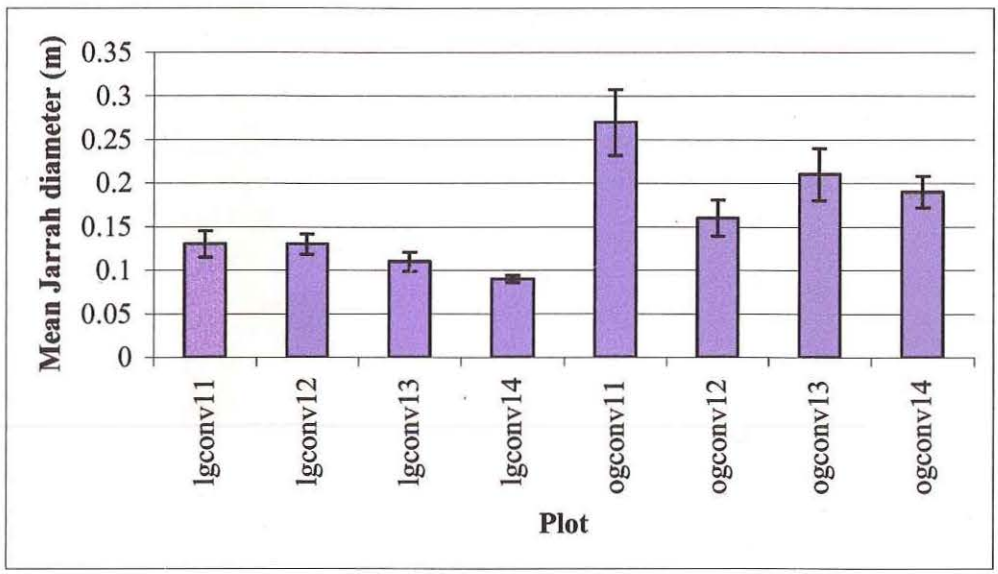

Figure 3.11 An example of the variability in mean jarrah tree diameter of plots, showing standard error.

The mean jarrah tree diameter also relates to the distribution of tree sizes of logged and oldgrowth sites. An example has been given of size class distribution of jarrah trees for all plots from the logged and oldgrowth forest sites at the Conveyor area (Figures 12 and 13). Both the logged and oldgrowth sites are dominated by trees in the 0.10 metre size class (all trees 0.06 to 0.10 m diameter). However, the logged site has a magnitude about four times higher (i.e. LG = 130 trees, OG = 35 trees). The main feature of significance was that the oldgrowth forest site at the Conveyor area had a size class distribution with a less-steep normality curve, only gaps in the structure above the maximum of the logged tree sizes, and larger overall tree diameters. In particular the logged site had double the number of trees compared to the oldgrowth (266 and 135 trees, respectively) and a lower mean diameter (0.11 and 0.19 m, respectively).

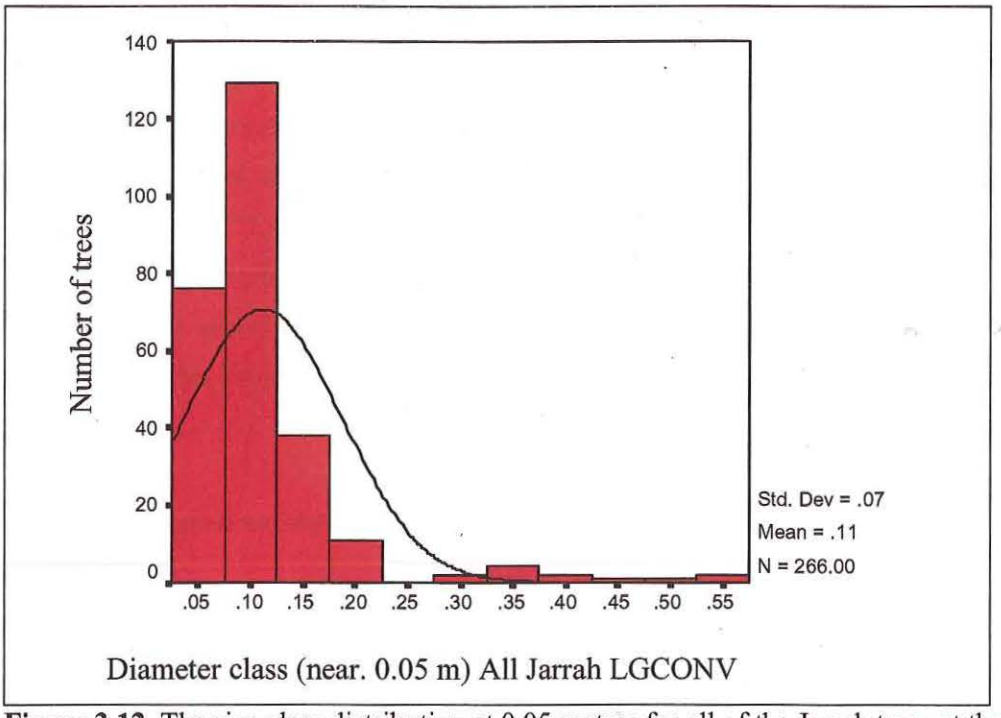

Figure 3.12 The size class distribution at 0.05 metres for all of the Jarrah trees at the logged Conveyor site. A normal curve and sample statistics have been provided.

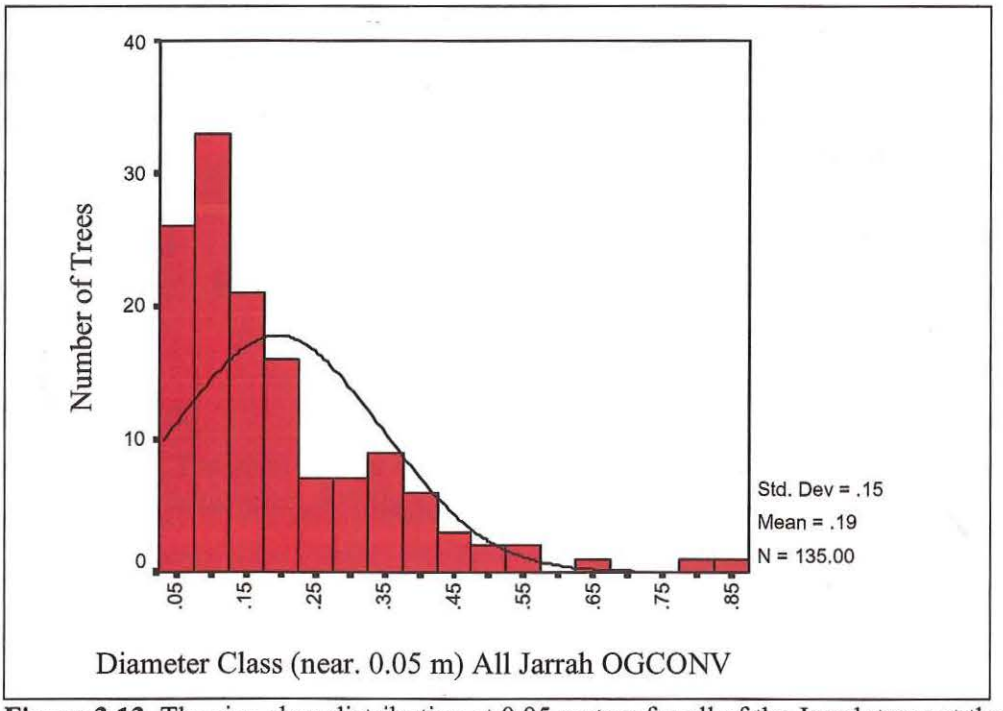

Figure 3.13 The size class distribution at 0.05 metres for all of the Jarrah trees at the oldgrowth Conveyor site. A normal curve and sample statistics have been provided.

The mean diameter for Jarrah trees was higher at all of the oldgrowth sites relative to their corresponding logged site, with the exception of the first pair of sites at Edison Mill Road. The mean Jarrah diameter for the first pair of sites at Edison Mill Road was slightly higher at the logged site, and these were only about one centimetre different (LG = 0.27 m, OG = 0.26 m). The first pair of sites at Edison Mill Road was also the pair with the largest mean Jarrah tree diameter and standard error. Curiously, the second pair of sites at Edison Mill Road had the smallest mean diameter, despite being in the same area as the previous pair of sites.

3.8.1.4 The mean number of jarrah trees for each site

The logged and oldgrowth sites at the Canning area were the only pair that showed a significant difference in the mean number of Jarrah trees within a pair (Figure 3.14).

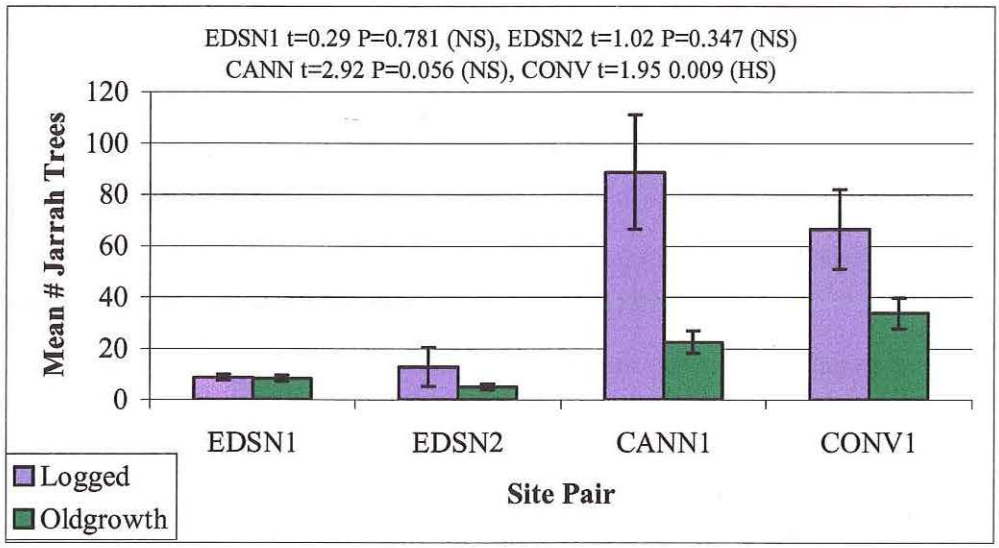

Figure 3.14 The mean number of Jarrah trees at each site. Showing +/- 1 SE. HS = Highly significant result, S = Significant result, NS = Not significant.

3.8.1.3 The mean diameter of all trees

There was a highly significant difference between the mean tree diameters for the logged and oldgrowth sites for the first pair at Edison Mill Road, no significance for this variable at the Canning area, and a significant result for the Conveyor area (Figure 3.15).

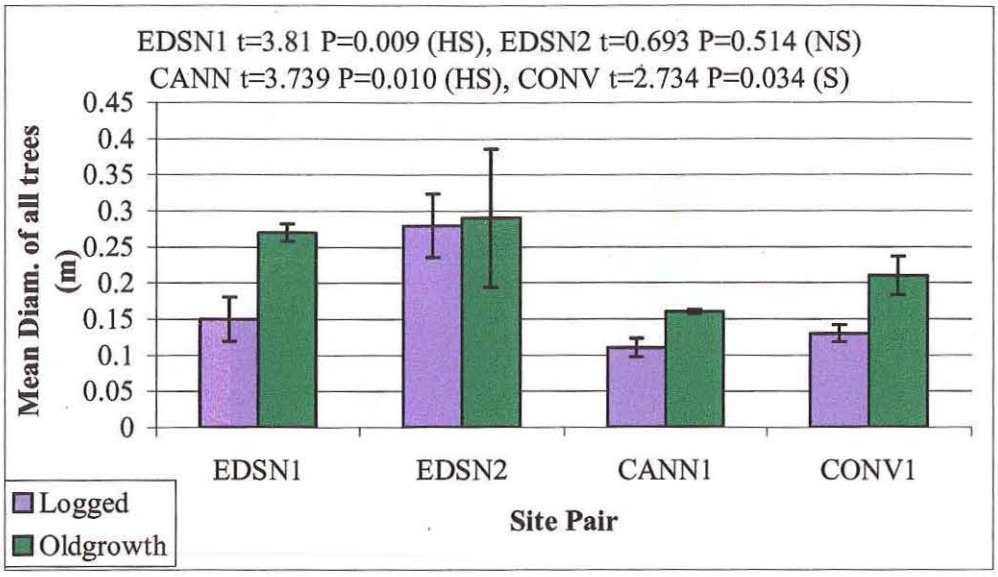

Figure 3.15 The mean diameter in metres of all trees at all sites. +/- 1 SE bars have been included to show the variability between plots within the same site. HS = Highly significant result, S = Significant result, NS = Not significant.

3.8.1.4 The difference in mean number of all trees between site pairs

There were no site pairs that showed a significant difference in the mean number of trees from all species. No results will be presented for this subsection.

3.8.1.5 The differences in basal area (BA) between sites

The Basal Area (BA) differences between sites varied depending on tree composition and the measuring device used (BA Prism or Dendrometer). Of the logged and oldgrowth sites from the same pair, the second from the Edison Mill Road area and the Canning pair had a significant result for difference (Figure 3.16). The significant differences were observed from the Dendrometer II data. The first Edison Mill Road site and the Conveyor site had P scores near the significance level of 0.05 for difference in BA.

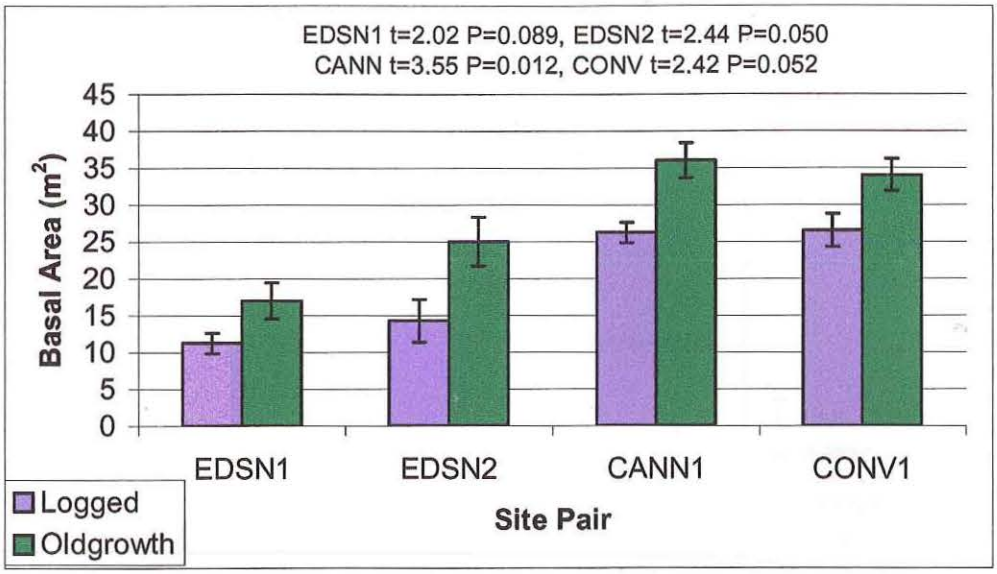

Figure 3.16 The mean Basal Area (BA) of all sites showing bars for +/- 1 SE.

3.8.2 Soil Differences between logged and oldgrowth jarrah forest

3.8.2.1 Soil differences between the first pair of Edison Mill Road sites

The soil from the logged site from the first pair was significantly lower (10 – 20 % lower) in sulphur and organic carbon content than the oldgrowth site (Figure 3.17).

3.8.2.2 Soil differences between the second pair of Edison Mill Road sites

The soil from the logged site in the second pair from Edison Mill Road was also significantly lower in sulphur and organic carbon, and had a significantly higher percentage of gravel than the logged site (Figures 3.18 and 3.19).

3.8.2.3 Soil differences between the pair of sites at the Canning area

The logged site at the Canning area had significantly higher mean soil sulphur content and lower phosphorus and potassium content than the oldgrowth site (Figures 3.20 & 3.21). The relationship for sulphur was opposite to that found at the Edison Mill Road area.

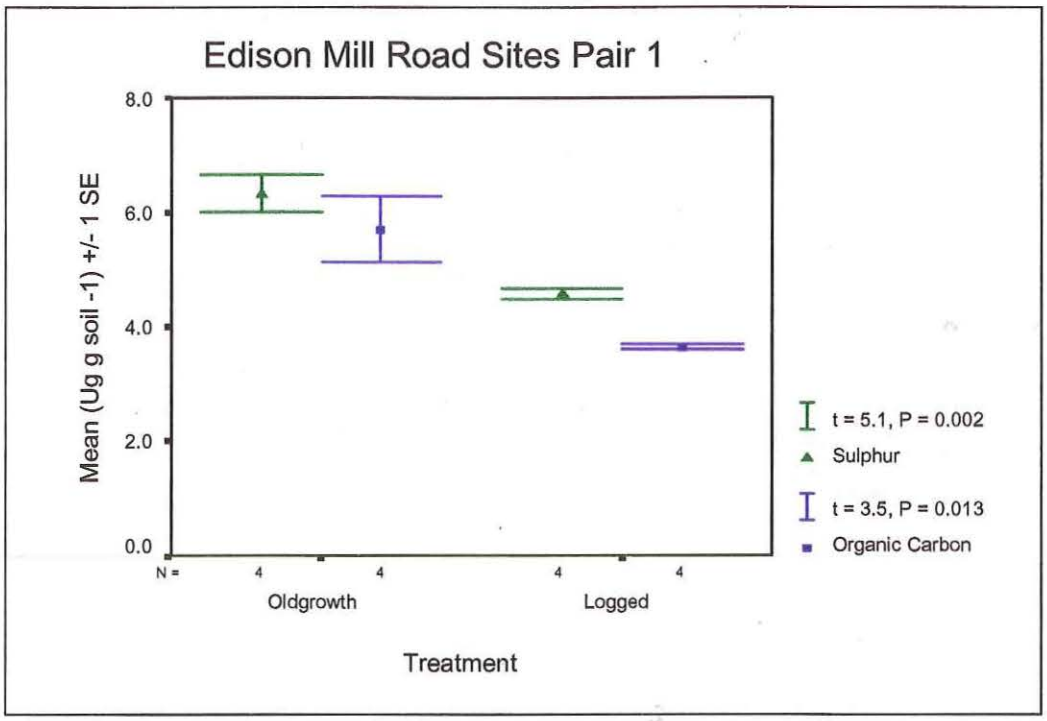

Figure 3.17 The difference in soil organic carbon and sulphur between the logged and oldgrowth site for the first Edison Mill Road pair. Bars represent +/- 1 SE.

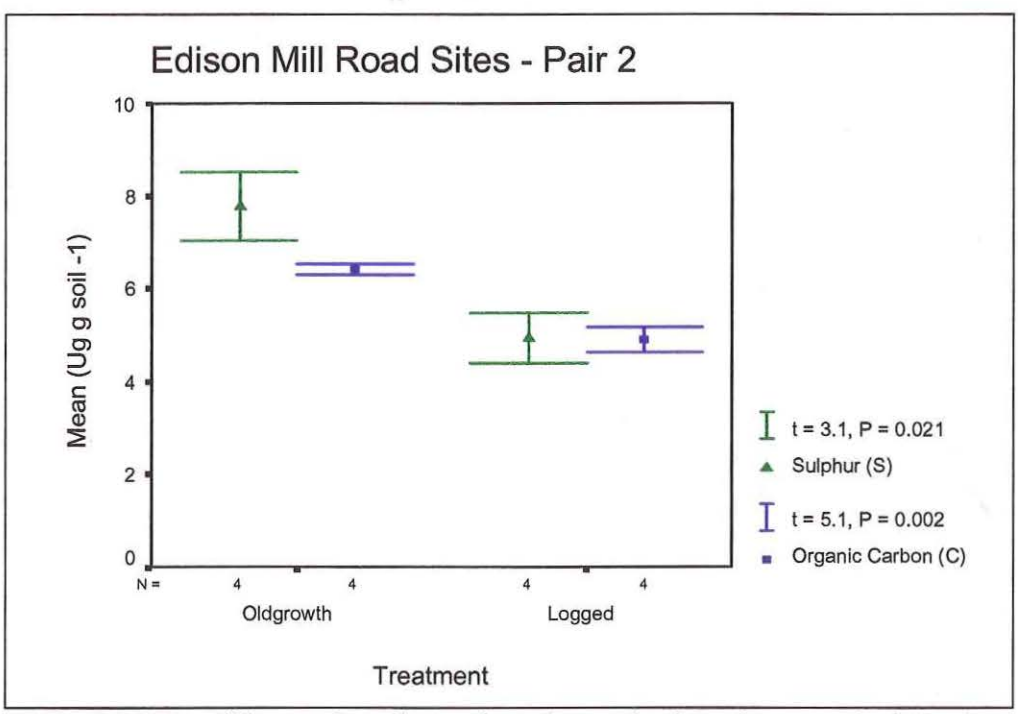

Figure 3.18 The difference in soil organic carbon and sulphur between the logged and oldgrowth site for the second Edison Mill Road pair. Bars represent +/- 1 SE.

Figure 3.19 The difference in soil gravel fraction (% mass) between the logged and oldgrowth site for the second Edison Mill Road pair. Bars represent +/- 1 SE.

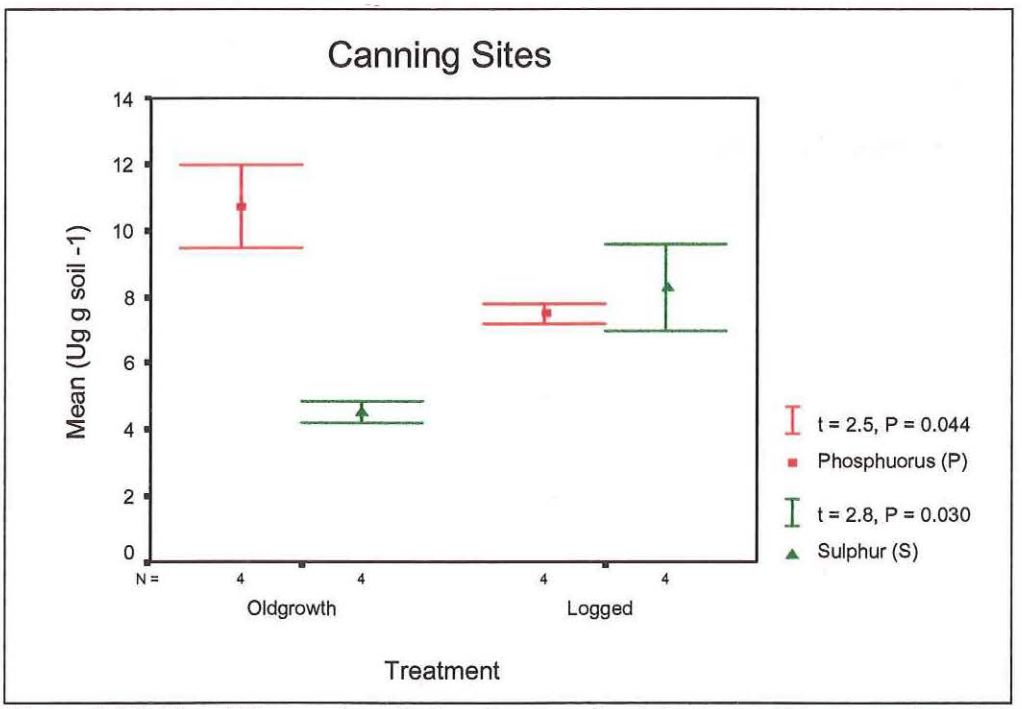

Figure 3.20 The difference in soil phosphorus and sulphur content between the pair of logged and oldgrowth sites for the Canning area. Bars represent +/- 1 SE.

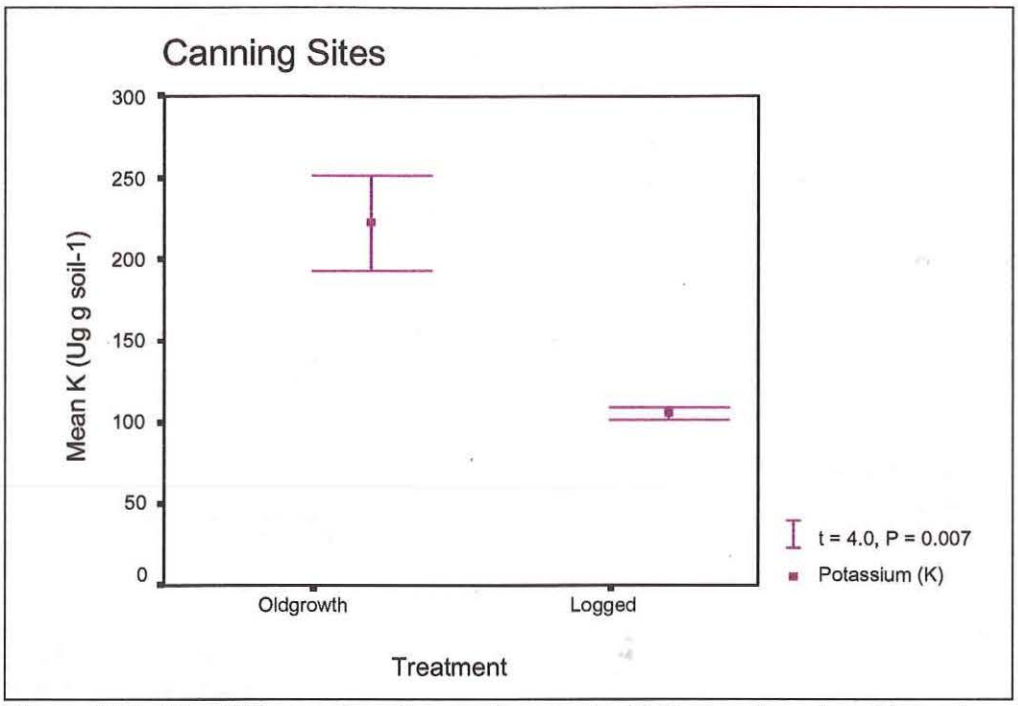

Figure 3.21 The difference in soil potassium content between the pairs of logged and oldgrowth sites for the Canning area. Bars represent +/- 1 SE.

3.8.2.4 Soil differences between the pair of sites at the Conveyor area

The oldgrowth site at the Conveyor area had significantly higher soil content of phosphorous and percentage gravel by mass than the logged site (Figure 3.22 & 3.23).

3.8.2.5 Soil texture and gravel content

There were no significant differences using t-tests for soil texture between any of the site pairs. Gravel content was not significantly different for the first site pair at Edison Mill Road and for the Conveyor sites.

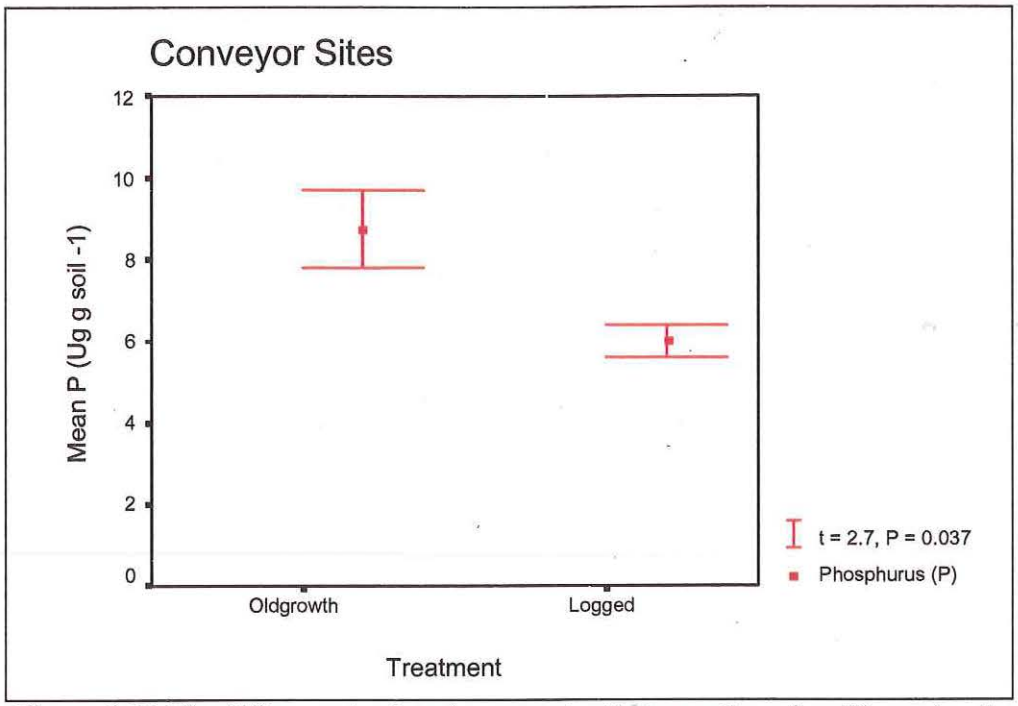

Figure 3.22 The difference in phosphorus content between the pairs of logged and oldgrowth sites for the Conveyor area. Bars represent +/- 1 SE.

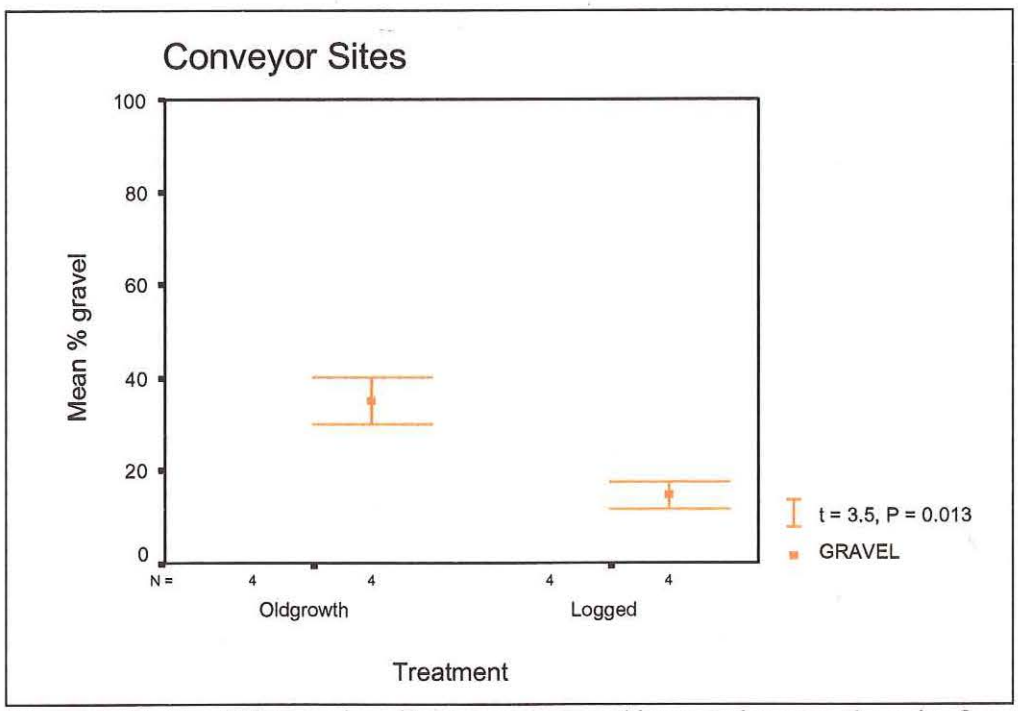

Figure 3.23 The difference in soil percentage gravel by mass between the pair of logged and oldgrowth sites for the Conveyor area. Bars represent +/- 1 SE.

3.8.2.6 Nitrate nitrogen, Ammonium, Phosphorus and Potassium in soil

The soil samples tested from showed no significant difference for nitrate nitrogen or ammonium (all site pairs), phosphorus (at both EDSN sites and the Canning sites) and potassium (both EDSN sites and the Conveyor site).

3.8.2.7 Soil sulphur and organic carbon

Sulphur and organic carbon were not significantly different between sites of the same pair for the Canning area (sulphur only) and the Conveyor area (both sulphur and organic carbon).

3.8.2.8 Soil Iron and electrical conductivity

All of the site pairs had no significant difference between logged and oldgrowth areas for soil iron (Fe) content. The electrical conductivity of soil solution also had no significant differences between oldgrowth and logged sites from the same pair.

3.8.2.9 Soil differences across treatments

The logged sites from all areas had significantly higher soil nitrate nitrogen ($t=2.39$ $P=0.048$) compared to the oldgrowth sites. Sulphur and organic carbon were significantly higher (sulphur $t = 4.39$ $P = 0.001$, organic carbon $t = 4.35$ $P = 0.001$) across all sites for the oldgrowth treatment compared to the logged treatment. All other soil variables were not significantly different between the logged and oldgrowth treatments at a regional level (across areas).

3.9 Biological and Environmental Correlations

The BIOENV analysis showed that across all areas, the composition of the cryptophyte flora (a combination of presence/absence and abundance) had the highest correlations with the following variables: the mean number of trees from all

species (r = 0.536), litter depth (r = 0.429), slope (r = 0.419) and the mean number of Jarrah trees (r = 0.336). There were no reasonable correlations for any environmental variable with cryptophytes between the two pairs of sites at Edison Mill Road. The first pair of Edison Mill Road sites showed moderate correlations between the cryptophytes and the variables: mean jarrah diameter (r = 0.558), competition by species richness (r = 0.375) and number of trees from all species (r = 0.300). The second pair of sites at Edison Mill Road had moderate correlations between cryptophytes and litter depth (r = 0.463). The Canning sites had moderate correlations between cryptophyte composition and the environmental variables of basal area (Prism r = 0.668, Dendrom. r = 0.651), mean diameter of all trees (r = 0.643), the number of Jarrah trees (r = 0.593), slope (r = 0.444), mean diameter of Jarrah (0.382) and litter depth (r = 0.308). The Conveyor sites had cryptophyte composition and slope showing a moderate correlation (r = 0.517).

CHAPTER 4

4.0 DISCUSSION

At the site pair scale, cryptophyte composition (a product of species presence/absence and abundance) showed that each of the logged sites was significantly different from the paired oldgrowth site. These differences will be discussed will be discussed further in relation to composition of all plant species and the environmental factors considered in this study.

Cryptophyte Differences

Differences Between All Sites

The cryptophytes (and small hemicryptophytes) were different between all logged and oldgrowth sites within each pair and between areas. The cluster diagrams and MDS showed patterns that grouped cryptophyte composition mainly in relation to the geographic position. However, the cryptophytes for the Canning area while being about 30 % closer to Edison Mill Road than the Conveyor area were the most isolated group in clustering and ordination space. This distinctness related to the fact that there were few similar cryptophyte/hemicryptophyte species with other areas. In addition, the Conveyor area was geographically the most displaced of all three areas.

The oldgrowth sites tended to have a higher percentage similarity of cryptophytes between the plots, relative to the logged site with which they were paired. This similarity is likely to be a factor of the less variable conditions found in the relatively undisturbed soil environments. The soil disturbance by machinery

rubber-tyred machinery occurs during and after logging operations is very likely to affect regenerating plants such as cryptophytes and hemicryptophytes. Indeed, tyre disturbance of soil is a regular and deliberate practice in many Jarrah forest areas used to promote seedbed stimulation for jarrah plants (CALM 1997).

There was a significant difference between the logged and oldgrowth sites of each of the four pairs based on cryptophyte abundance and composition. This was also true for between the areas using sites as treatment samples. At Edison Mill Road, there was no significant difference between the two sites within each treatment. So this means that the logged areas had significantly different cryptophyte composition from oldgrowth forest at regional as well as local levels.

In relation to particular species, the contribution to dissimilarity by *Drakaea gracilis* may have been the highest for the first pair of site at Edison Mill Road because of the local geology. Both of the sites had reasonable proportion of open areas with small pisolite gravel and soil over laterite. Hoffman and Brown (1992) suggest that this species has a preference for shallow soil over massive laterite. The higher average abundance of *D. gracilis* at the logged site may relate to the significantly higher soil organic matter content displayed at the oldgrowth site (by organic carbon in the soil). However, all *Drakaea* tend to prefer open areas such as old tracks (Hoffman and Brown 1992), which contrasts with the finding of higher abundance in the closed oldgrowth forest relative to open logged forest.

Ptilotus manglesii has been regularly seen in the field resprouting after fire and widely colonising open areas. The high average abundance at the for the logged and oldgrowth site in the first pair for Edison Mill Road was a reflection of the capacity for *P. manglesii* to grow with and also without recent fire and abundant open areas. *Stylidium amoenum* may have had a higher abundance at both Edison Mill Road oldgrowth sites relative to the logged sites for reasons of forest structure. This species was mostly found in shaded areas in reasonably thick litter. Although the litter depth was not significantly different between the site pairs, BIOENV did indicate a reasonable correlation of this factor with cryptophyte composition in

general. Although not directly measured, the idea that the logged sites of each pair would in general have less shade than the corresponding oldgrowth site would be supported by tree size class data, personal observation and awareness of the overstorey loss during logging.

Drosera stolonifera had a higher average abundance at the first logged site, which may have reflected the preference of this species for locations with limited inter-species competition. At both pairs of sites at Edison Mill Road, *Drosera scorpiodes* had a consistent pattern of presence and abundance at the oldgrowth and logged sites respectively. The presence of *D. scorpiodes* only at both the oldgrowth sites and *Drosera glanduligera* at the only the second logged site from Edison Mill Road suggests that the site factors can be important for determining what species are present.

One very important feature of the cryptophyte abundances for the sites at Edison Mill Road was that both of the oldgrowth sites had higher abundance of about 80 % (11 spp.) of the plant species contributing 75 % (14 spp.) of the dissimilarity with the logged site in each pair. These taxa included species from the Orchidaceae, Styliaceae, Haemodoraceae and Droseraceae.

However, the presence and abundance of the orchid species *Pyrochis nigricans* did not conform to expected patterns. This species has often been found abundantly growing in old ashbeds, and this was the case at the logged site of the first pair of sites for Edison Mill Road, while absent from the oldgrowth site. The complication in trying to answer whether logging was having an effect on this species comes from the second pair of sites. Instead of finding a similar patter, the second pair of sites had the complete opposite pattern for *P. nigricans*, with species quite abundant in the thick vegetation and litter of the oldgrowth site. This sort of variability over a spatial scale of several hundred metres is cause for concern as it indicates a limitation of drawing conclusions from these data. Fortunately, this sort of disparity of presence and abundance was not a frequent occurrence for other cryptophytes species at Edison Mill Road.

The high dissimilarity contributions made by *Clematis pubescens* and *Ranunculus colonorum* at the Canning sites were factors that might be a reflection of a more closed-in canopy in the absence of logging. These species along with the rhizomatous bracken fern *Pteridium esculentum*, may benefit from additional shading and soil moisture than might be preserved more so in oldgrowth compared to logged forest. However, it is possible that the characteristics that allowed for the three species mentioned above that were abundant in oldgrowth forest, prevented other species from persisting. Three *Stylidium* species and *Burchardia umbellata* were either only suited to growing at the Canning logged site, or were more abundant there.

The main differences between cryptophytes at the Conveyor area related to the high abundance of many cryptophyte/hemicryptophyte plant species that form rosette leaf arrangements. The Asteraceae plant species *Craspedia variablis* and *Trichocline spathulata* were quite common in the logged area and less so for the oldgrowth area. Interestingly, another plant from the same family *Lagenophora huegellii* was reasonably consistent between the logged and oldgrowth sites at the Conveyor area. The species *Chamaescilla corymbosa* contributed only a limited amount to the dissimilarity despite having a mean abundance 50 % lower in the oldgrowth area. Of the top eight species contributing 75 % dissimilarity, more species (5) were found at the logged site compared to the oldgrowth site. The Orchidaceae was once again represented best in the oldgrowth site.

The significantly higher abundance of cryptophytes in oldgrowth forest for three of the four site pairs (including both EDSN pairs and the Canning site) suggested that this forest type is generally more suited for persistence. While the conveyor site had a significant relationship in the opposite direction, other research would support the unlogged forest preference by cryptophytes. In a short-term study by Burrows *et al.* (2002), there was a disproportionably high number of plants that regenerate from fleshy storage organs such as cryptophytes, which were reduced in abundance by gap and shelterwood logging. However, Burrows *et al.* (2002) were

looking at Jarrah forest that cut over in 1995/96 and/or 1940s/60s, with or without a 1996 burn. So the comparison with this work is limited by the fact that the Burrows (2002) study was affected by relatively recent fire, while this study was not.

Environmental Differences

The moderate relationship between soil organic carbon and cryptophyte abundance and composition was reflected in the patterns for many of the orchid species found. It is likely that the higher abundance of many of the orchid species at Edison Mill Road may be related to the soil organic matter because soil microflora. The mycorrhizal soil fungi on which many orchids have dependence can be in turn dependent on the availability of adequate soil organic matter and moisture. Grove *et al.* (1986) found that nutrients can remain concentrated in surface soils following fire. It is possible that the nutrient differences in the soils of the logged and oldgrowth areas are related to the capacity for nutrients to be retained or available by particular soil characteristics (e.g. pH, organic carbon, texture).

Mean litter depth varied, but was generally greater in oldgrowth areas and this would be likely to affect soil organic matter as expressed as organic carbon. Organic carbon and sulphur were higher in oldgrowth areas for the drier Edison Mill Road site, which may be a factor of slow decay of leaf and wood material and consistent supply to the litter layer. At the Canning and Conveyor areas, rainfall is possibly more consistent and less of a limiting factor for soil moisture and cryptophyte survival. Litter depth may be recovered fairly quickly after logging in these situations. Indeed, Wallace and Hatch (1952) found that a higher dry weight of litter was produced in regenerating forest than virgin (oldgrowth) forest.

The reason for soil sulphur being higher at the logged site of the Canning pair may be a product of soil type and the overstorey. O'Connell *et al.* (1978) suggest that the composition of nutrients in litter is highly dependant on the plants that supply the material and soil type. In the nutrient deficient soils of the jarrah forest, it

is likely that cycling of nutrients through litter is very important for maintaining the health and productivity of this ecosystem (O'Connell 1978). These reasons may explain why phosphorus was higher in oldgrowth forest compared to the logged forest at the Canning and Conveyor areas, and potassium with the same pattern for the Canning area. The higher nutrient concentrations for phosphorus and potassium may explain why the oldgrowth sites for the Canning and Conveyor areas had highly significant differences for cryptophyte abundance and no difference for cryptophyte species richness. The additional nutrients may have been able to support a few species that could dominate the community of plants in this group.

Slope was possibly associated with cryptophyte composition for two reasons: many favourable oldgrowth areas are restricted to less accessible slopes, and the slopes and uplands tend to be species rich in Western Australia (Hopkins *et al.* 1983). There does not seem to be more to the explanation than simply the location of the remnant oldgrowth areas, with soil type etc. not different in this study.

In relation to other explanations for differences, Burrows *et al.* (2002) suggested a list of possible causes of reductions in taxa that include cryptophytes following logging. The reasons included soil disturbance and damage, physical damage to vegetation, silvicultural burning, post-logging burning, and a combination of these factors (Burrows *et al.* 2002). The Burrows (2002) study was semi-controlled for reasons two to four on the list, by time since logging, and therefore this would suggest that soil disturbance is likely to be a key factor limiting cryptophyte abundance.

Major soil disturbance has been shown to locally reduce or eliminate species that persist through life forms using regeneration strategies (Grant and Koch 2003). The lower percentage similarity for cryptophytes at the logged sites (with the exception of the Conveyor site) is likely to correspond to a limited similarity in soil conditions across logged sites due to disturbance. Alternatively, it could be suggested that the oldgrowth sites may have spatially less variable light, soil

moisture and other conditions that are more suited to regenerators such as cryptophytes.

Stand structure is one of the forest conditions that is very likely to affect what plants can persist through disturbance events. The process of logging has the primary effect of changing stand structure. The list produced by Burrows *et al.* (2002) of suggested reasons for reductions in plant taxa seem to have omitted the effect of modifying forest structure as a possible cause of change in plant communities.

The structural differences in the jarrah forest sampled were beyond simply the number of trees present. The different mean sizes and size class distributions are likely to have had a number of effects. Lindenmayer and Franklin (1997a) highlight the importance of structural diversity in forests with the presence of old senescent trees allowing for 'recruitment' of logs on forest floors, providing heterogeneity on the ground. It could also be suggested that larges decaying logs could provide a supply of litter/organic matter to the soil for use my soil mycorrhizal fungi and dependant plants such as cryptophytes. Indeed the presence of large decaying logs in forests has been described as part of an ecological process for individual trees and forests (Franklin *et al.* 1987). So logging may reduce the potential for recruitment of logs, which may have flow on effects for ecosystem functioning and the capacity for forests to support plants and biodiversity in general.

The size and abundance of logs in forest areas may affect cryptophyte composition. Franklin *et al.* (1987) and Lindenmayer *et al.* (2002) suggested that logs are important nursery grounds for some plants, provide heterogeneity in the litter layer and a continual supply of nutrients. This variety of conditions and supply of nutrients is very likely to be crucial for some cryptophytes. Indeed, observations during the course of this study found cryptophytes from the Orchidaceae in particular often growing alongside or under gaps in old logs.

The moderate correlations of cryptophytes with number of trees, litter depth and slope and mean number of Jarrah trees suggest a number of things. More trees are likely to add competition for light and nutrients. The logged sites were greatly dominated by young trees (stem coppice and single stems) and ground coppice growth. This all would have added to competition and limited the capacity of cryptophyte persistence.

CHAPTER 5

5.0 CONCLUSIONS

Cryptophyte abundance can vary between logged and oldgrowth jarrah forest areas. Cryptophyte abundance can be higher, although not necessarily significant for oldgrowth forest compared to logged jarrah forest in drier areas over the medium timescale. The abundance of cryptophytes can be higher for jarrah forest in the medium term following logging or for oldgrowth forest depending on geographic position and other factors. Over the medium timescale, logged forest tends to have lower species richness for cryptophytes compared to oldgrowth forest in drier areas. Wetter jarrah forest areas may have no difference in the number of cryptophyte species found between forest in the medium term following logging and for oldgrowth areas.

Cryptophyte composition, as a product of species presence/absence and the abundance, shows that some jarrah forest areas differ in the medium term following a selection cutting event when compared to oldgrowth. Logging in the form of heavy selection cutting and gap thinning is likely to lead to a long-term decline in cryptophytes and other plants that regenerate from below ground fleshy storage organs. The direct reasons for the decline are likely to be related to competition from future crop trees, soil disturbance and reductions in site heterogeneity.

In drier jarrah forest areas, a medium timescale after selection cutting may not be adequate for the recovery of soil properties of organic carbon and sulphur to levels found in oldgrowth forest. The lower soil concentrations of these elements may limit the capacity for the logged jarrah forest areas to support cryptophytes.

In the central and western jarrah forest areas that tend to experience more rainfall, phosphorus and potassium may be lower in areas that were last logged in the medium term of roughly 15 to 30 years ago. Lower levels of these nutrients may act to limit dominance of some cryptophytes in these jarrah forest areas.

In the medium term following selection cutting, logged jarrah forest areas are structurally different to oldgrowth areas. These logged areas can have more trees than oldgrowth areas due to regeneration but it may not be significant. However, more any additional trees are likely to limit cryptophytes through competition for light and space. Oldgrowth jarrah forest can have larger mean diameters for jarrah and all tree species, and also larger basal area, which may all provide structural diversity to support the provision of shade patchiness, litter fall, logs and so on.

Maintaining structural diversity may be important for the supply of organic matter to the soil and retention of soil moisture. While cryptophytes have a capacity through storage organs to persist through unfavourable weather, disturbance to stand structure and soil during logging operations can influence these plants. The disturbance can mean that even in the medium timescale that cryptophyte composition does not return to a condition found in oldgrowth forest. However, cryptophyte composition in the northern jarrah forest is partially determined by geographic position. Logged forest environments in the medium term following the disturbance are able to support cryptophyte species that are not found in oldgrowth forest, but that many other species can exist in the latter type.

It seems that a combination of factors affect cryptophyte composition in forest areas at the medium term after logging compared to oldgrowth areas. Stand structure may be simplified during logging through the removal of many larger trees and the regeneration of many young smaller diameter trees. This simplification of stand structure may combine with other factors not considered in this study to affect cryptophyte composition. Such other factors could be soil disturbance from machinery and fire happening in the same year as the logging.

This study would recommend the retention of a greater range in tree sizes for the maintaining a diversity in stand structure, while providing for potential new logs and heterogeneity in shade, leaf fall and litter depths. This may allow for the maintenance of niche environments/nutrient sources for cryptophytes and other plants. Also, there may be a need to retain a greater diversity of tree sizes to provide a source of future logs. In addition to sustaining some structural diversity, it is recommended that other factors that may affect cryptophytes such as post-logging soil disturbance for receptive seedbed generation also be revised.

There may also be a need to review the systems used for logging, so that plant disturbance is minimised during and after the event. Such reviews might include consideration of a transition to practices that retain 'understorey islands' to limit the direct impacts and allow for reinvasion by species. By retaining 'islands' of structural diversity with heterogeneity of shade and litter etc., cryptophytes may reinvade disturbed areas over a shorter timeframe. This may reduce deleterious effects of selection cutting on cryptophytes in the medium term, such as altered abundance, species richness and overall composition.

While this research was limited in that it covered only three small areas of the northern jarrah forest and therefore represented only a low percentage, it was carefully designed to reduce the effects of geographic differences between logged and oldgrowth areas. As such, this research has shown that cryptophytes composition does differ between oldgrowth forest and areas in the medium term following logging. Ecological diversity can be maintained by ensuring that some logged areas are managed to provide the necessary structure to support soil processes, plant persistence and possibly animals that rely on these things.

I would recommend that there would be value in conducting future studies that consider the specific roles of logs, soil organic matter and moisture, shade and disturbance regimes for the maintenance of cryptophytes and other regenerating plants. By developing a better understanding of the requirements of species of particular life forms, we may be able to achieve the goal of ecologically sustainable

forest management. With a better understanding of the processes of disturbance we may be able to manage all of the components of the diverse and unique understorey plants of the Jarrah forest, and perhaps biodiversity for forests in general.

CHAPTER 6

6.0 REFERENCES

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CHAPTER 7

7.0 APPENDIX

Appendix 1

Species Compos. 0 = absent, 1 = rare, 2 = <1 %cover, 3 = 1 - 5% Cover, 4 = 5 - 50% cover, 5 = >50% cover

FAMILY	TAXON	LGCANN11	LGCANN12	LGCANN13	LGCANN14	OGCANN11	OGCANN12	OGCANN13	OGCANN14
Anthericaceae									
	Chamaescilla corymbosa	0	1	0	0	0	0	0	0
	Thysanotus patersonii	0	0	0	0	0	0	1	0
	Thysanotus ?tenellus	0	0	0	0	0	0	0	1
Apiaceae									
	Pentapeltis peltigera	1	1	1	1	0	0	0	0
	Platysaceae juncea	1	2	2	0	0	1	1	0
Asparagaceae									
	**Myrsiphyllum asparagoides*	0	0	0	0	1	1	0	0
Asteraceae									
	**Conyza bonariensis*	0	0	0	2	2	2	1	1
	Craspedia variablis	0	0	0	0	3	0	0	0
	Hyalospema cotula	0	0	0	0	0	0	0	0
	**Hypochaeris glabra*	0	0	0	0	0	0	0	1
	Lagenifera huegelii	3	3	3	3	3	3	3	3
	Senecio hispidulus	0	0	0	0	0	0	0	0
	Trichocline spathulata	0	0	0	0	3	0	0	0
	Asterac. white rolled petals	0	0	0	0	0	0	0	0
	Rhodanthe citrina?	0	0	0	0	0	0	0	0
Boraganaceae									
	Halgania corymbosa	0	0	0	0	0	0	1	0
Colchicaceae									
	Burchardia umbellata	2	1	2	2	1	0	1	3
Cyperaceae									
	Lepidosperma tenue	1	0	0	0	0	0	0	0
Dasypogonceae									
	Lomandra caespitosa ?	0	0	0	0	0	0	0	0
	Lomandra odora? 400x 0.5mm	1	2	1	1	0	0	0	0
	Lomadra purpurea	0	0	0	0	0	0	0	0
	Lomandra sonderii? 500x5mm	1	0	2	0	0	0	0	0
	Lomandra sp. 1 280x1.5mm	0	0	0	0	0	0	0	0
	Lomandra sp.2 80 x 1 mm	1	0	0	0	0	0	0	0
	Lomandra 'small grey'	0	1	1	1	0	0	0	0
	Lomandra sp. 3 120x4mm	0	0	0	1	0	0	0	0
	Lomandra 350x4 mm twisted	0	0	0	0	0	0	0	0
Dennstaedtiaceae									
	Pteridium esculentum	0	0	0	0	0	3	2	3
Dillenaceae									
	Hibbertia acerosa	0	0	0	0	0	0	0	0
	Hibbertia amplexicaulis	3	2	2	2	2	2	2	1
	Hibbertia commutata	0	0	0	0	0	0	2	2
	Hibbertia hypericoides	4	3	4	3	0	0	0	0

Appendix 1 - cont.

Species Compos. 0 = absent, 1 = rare, 2 = <1 %cover, 3 = 1 - 5% Cover, 4 = 5 - 50% cover, 5 = >50% cover

FAMILY	TAXON	LGCANN11	LGCANN12	LGCANN13	LGCANN14	OGCANN11	OGCANN12	OGCANN13	OGCANN14
Droseraceae									
	Drosera erythrorhiza	0	0	0	0	0	0	0	0
	Drosera pallida	1	0	1	1	0	0	0	0
	Drosera stolonifera	0	0	0	0	0	0	0	0
Epacridaceae									
	Astroloma ciliatum	0	1	0	0	1	0	1	0
	Astroloma pallidum	0	0	0	0	0	0	0	0
	Leucopogon propinquus	2	1	2	1	2	2	2	1
	Leucopogon pulchellus	3	3	2	3	1	2	3	3
	Leucopogon verticillatus	2	2	2	2	1	2	2	2
	Leucopogon sp.3	2	0	0	0	0	0	0	0
Euphorbiaceae									
	Phyllanthus calycinus	0	3	2	1	2	1	3	4
Fabaceae									
	Bossiaea aquifolia	2	0	0	1	0	0	0	0
	Bossiaea ornata	2	2	3	2	0	0	0	0
	Gompholobium marginatum	1	0	0	1	0	0	0	0
	Hovea chorizemifolia	0	1	0	0	0	0	0	0
	Hovea elliptica	2	0	0	0	0	0	0	0
	Kennedia coccinea	0	2	1	2	0	1	0	0
	Kennedia prostrata	0	0	0	0	0	0	0	0
Goodeniaceae									
	Lechenaultia biloba	0	0	0	0	0	0	0	0
	Scaevola calliptera	1	0	0	1	0	0	0	0
Haemodoraceae									
	Haemodorum sp.1	0	0	0	0	0	0	0	0
Iridaceae									
	Patersonia babianoides	0	0	1	1	0	0	0	0
	Patersonia occidentalis	0	0	1	0	0	0	0	0
Lauraceae									
	Cassytha racemosa	0	0	0	0	1	0	0	0
Mimosaceae									
	Acacia decurrens	1	0	0	0	0	0	0	0
	Acacia drummondii	0	0	0	0	0	0	0	0
	Acacia extensa	1	1	1	0	0	0	0	0
	Acacia lasiocarpa	0	0	0	0	0	0	0	0
	Acacia pulchella	1	0	1	0	0	1	0	2
	Acacia saligna	0	0	0	0	0	0	0	0
	Acacia urophylla	2	2	2	2	0	0	2	0
	Acacia sp.5 phyllode	0	0	0	0	1	0	0	1
Myrtaceae									
	Corymbia calophylla	4	2	2	0	3	4	3	3
	Eucalyptus marginata	5	5	4	4	1	2	4	3
	Euaclyptus patens	0	0	0	0	0	0	0	0
	Hypocalymma angustifolium	0	0	0	0	0	0	0	0

Appendix 1 - cont.

Species Compos. 0 = absent, 1 = rare, ? = <1 %cover, 3 = 1 - 5% Cover, 4 = 5 - 50% cover, 5 = >50% cover

FAMILY	TAXON	LGCANN11	LGCANN12	LGCANN13	LGCANN14	OGCANN11	OGCANN12	OGCANN13	OGCANN14
Orchidaceae									
	Caladenia flava	2	0	1	1	0	1	0	0
	Caladenia reptans	0	1	1	1	0	0	0	0
	Pterostylis barbata	0	0	0	0	2	0	0	0
	Pterostylis ?nana	0	0	0	0	0	0	0	0
	Pterostylis vittata	1	0	0	0	0	0	0	0
	Thelymitra crinita	0	0	0	0	0	0	1	0
Oxalidaceae	* *Oxalis corniculata*	2	2	1	2	2	2	2	3
Pittosporaceae									
	Pronaya fraseri	1	0	1	0	0	0	1	0
Poaceae									
	Briza maxima	0	0	0	0	0	0	1	0
	Briza minor	0	0	0	1	0	0	0	1
	Neurachne alopecuroidea	1	2	2	2	2	2	1	2
	Hairy grass	3	0	1	1	1	2	2	2
Primulaceae									
	* *Anagallis arvensis*	0	0	0	0	2	3	2	2
Proteaceae									
	Dryandra lindleyana	0	0	0	0	0	0	0	0
	Hakea lissocarpha	2	1	1	0	0	0	0	0
	Persoonia longifolia	1	0	0	0	0	0	0	0
Ranunculaceae									
	Clematis pubescens	3	1	2	2	4	4	4	4
	Ranunculus colonoratum	0	0	0	0	4	3	2	0
Rhamnaceae									
	Trymalium floribundum	3	1	0	2	4	2	2	2
	Trymelium ledifolium	0	0	0	0	0	0	0	0
Rubiaceae									
	Opercularia echinocephala	2	2	1	2	0	0	1	0
Rutaceae									
	Boronia fastigiata	0	0	0	0	0	0	0	0
Santalaceae									
	Leptomeria cunninghamii	0	0	1	0	0	0	0	0
Stylidiaceae									
	Stylidium amoenum	2	0	2	2	0	0	0	0
	Stylidium bulbiferum	2	3	1	0	2	3	3	2
	Stylidium calcaratum	1	0	2	2	2	2	3	2
	Stylidium ciliatum	0	0	2	2	0	0	0	0
Thymeleaceae									
	Pimelea preissii	0	0	0	0	0	0	0	0
Tremandraceae									
	Tetratheca hirsuita	0	0	1	0	0	0	0	0

Appendix 1 - cont.

Species Compos. 0 = absent, 1 = rare, 2 = <1 %cover, 3 = 1 - 5% Cover, 4 = 5 - 50% cover, 5 = >50% cover

FAMILY	TAXON	LGCANN11	LGCANN12	LGCANN13	LGCANN14	OGCANN11	OGCANN12	OGCANN13	OGCANN14
Xanthorrhoeaceae									
	Xanthorrhoea gracilis	2	2	0	1	3	3	1	2
	Xanthorrhoea preisii	4	3	3	3	4	4	4	3
Zamiaceae									
	Macrozamia riedlei	4	3	2	3	3	4	4	3
Unknown Taxa									
	Lily V-shaped leaf	0	1	0	0	0	0	0	0
	Small herb kidney leaf	0	0	0	1	3	0	0	0
	Fine grass	0	0	0	0	0	0	0	0
	Weedy rosette serrated leaflets	0	0	0	0	0	0	0	0
	Small hairy rush	0	0	0	0	0	0	0	0
	Small shrub lvs alternate	0	0	0	0	0	0	0	0
	Very small herb divaricate lvs	0	0	0	0	2	2	2	2

Appendix 1

Species Compos. 0 = absent, 1 = rare, 2 = <1 %cover, 3 = 1 - 5% Cover, 4 = 5 - 50% cover, 5 = >50% cover

FAMILY	TAXON	LGCONV11	LGCONV12	LGCONV13	LGCONV14	OGCONV11	OGCONV12	OGCONV13	OGCONV14
Anthericaceae									
	Chamaescilla corymbosa	3	3	3	2	1	2	2	3
	Thysanotus patersonii	0	0	0	0	0	0	0	0
	Thysanotus ?tenellus	0	0	0	0	0	0	0	0
Apiaceae									
	Pentapeltis peltigera	2	2	2	2	2	2	2	2
	Platysaceae juncea	0	0	0	1	1	1	1	1
Asparagaceae									
	* *Myrsiphyllum asparagoides*	0	0	0	0	0	0	0	0
Asteraceae					0				
	**Conyza bonariensis*	0	0	0	0	2	2	1	0
	Craspedia variablis	3	3	3	3	2	3	2	1
	Hyalospema cotula	2	1	1	2	0	2	2	2
	**Hypochaeris glabra*	0	0	0	0	0	0	0	0
	Lagenifera huegelii	2	2	2	2	2	1	3	3
	Senecio hispidulus	0	0	0	0	0	0	0	0
	Trichocline spathulata	3	3	3	3	2	3	2	0
	Asterac. white rolled petals	0	0	0	0	0	0	0	0
	Rhodanthe citrina?	0	1	0	1	2	1	1	1
Boraginaceae									
	Halgania corymbosa	0	0	0	0	0	0	0	0
Colchicaceae									
	Burchardia umbellata	3	2	2	1	1	1	1	2
Cyperaceae									
	Lepidosperma tenue	0	0	0	0	1	0	0	0
Dasypogoneae									
	Lomandra caespitosa ?	0	0	0	3	0	0	0	0
	Lomandra odora? 400x 0.5mm	1	1	1	1	0	0	0	0
	Lomadra purpurea	0	0	0	1	0	0	0	0
	Lomandra sonderii? 500x5mm	0	0	0	0	0	0	0	0
	Lomandra sp. 1 280x1.5mm	0	0	0	0	1	2	1	2
	Lomandra sp.2 80 x 1 mm	0	0	0	0	0	0	0	0
	Lomandra 'small grey'	0	0	0	0	0	0	0	0
	Lomandra sp. 3 120x4mm	0	0	0	0	0	0	0	0
	Lomandra 350x4 mm twisted	0	0	1	0	0	0	0	0
Dennstaedtiaceae									
	Pteridium esculentum	0	0	0	0	0	0	0	0
Dillenaceae									
	Hibbertia acerosa	2	0	0	0	1	1	1	2
	Hibbertia amplexicaulis	1	1	1	2	2	2	2	3
	Hibbertia commutata	3	3	3	3	3	3	3	3
	Hibbertia hypericoides	0	0	0	0	0	0	0	0

Appendix 1 - cont.

Species Compos. 0 = absent, 1 = rare, 2 = <1 %cover, 3 = 1 - 5% Cover, 4 = 5 - 50% cover, 5 = >50% cover

FAMILY	TAXON	LGCONV11	LGCONV12	LGCONV13	LGCONV14	OGCONV11	OGCONV12	OGCONV13	OGCONV14
Droseraceae									
	Drosera erythrorhiza	2	3	3	3	2	1	2	2
	Drosera pallida	1	1	0	0	0	0	0	0
	Drosera stolonifera	2	0	2	1	0	0	2	0
Epacridaceae									
	Astroloma ciliatum	0	0	0	0	1	0	0	0
	Astroloma pallidum	1	2	0	0	2	2	0	0
	Leucopogon propinquus	0	2	2	1	0	1	2	0
	Leucopogon pulchellus	2	1	2	2	3	2	2	2
	Leucopogon verticillatus	0	0	0	0	0	0	0	0
	Leucopogon sp.3	0	0	0	0	0	0	0	0
Euphorbiaceae									
	Phyllanthus calycinus	2	0	0	1	3	3	2	2
Fabaceae									
	Bossiaea aquifolia	0	0	0	0	0	0	0	0
	Bossiaea ornata	3	4	1	2	3	4	3	3
	Gompholobium marginatum	1	0	1	1	1	1	1	0
	Hovea chorizemifolia	1	0	0	0	0	1	0	0
	Hovea elliptica	0	0	0	0	0	0	0	0
	Kennedia coccinea	0	0	0	0	0	0	0	0
	Kennedia prostrata	1	0	0	0	0	0	0	0
Goodeniaceae									
	Lechenaultia biloba	1	2	1	1	0	0	2	2
	Scaevola calliptera	1	2	1	1	2	3	2	2
Haemodoraceae									
	Haemodorum sp.1	0	2	0	2	0	0	0	2
Iridaceae									
	Patersonia babianoides	0	0	0	0	0	0	0	0
	Patersonia occidentalis	0	0	0	0	0	0	0	0
Lauraceae									
	Cassytha racemosa	0	0	0	0	0	0	0	0
Mimosaceae									
	Acacia decurrens	0	0	0	0	0	0	0	0
	Acacia drummondii	0	2	1	1	0	1	3	1
	Acacia extensa	2	1	0	0	0	2	3	2
	Acacia lasiocarpa	1	2	3	1	2	2	1	2
	Acacia pulchella	0	0	0	0	3	0	1	1
	Acacia saligna	0	0	1	1	3	2	1	3
	Acacia urophylla	0	0	0	0	0	0	0	0
	Acacia sp.5 phyllode	0	0	0	0	0	0	0	0
Myrtaceae									
	Corymbia calophylla	1	0	0	0	0	0	1	1
	Eucalyptus marginata	4	4	4	3	3	4	3	4
	Euaclyptus patens	0	2	1	0	0	0	0	0
	Hypocalymma angustifolium	2	3	4	4	3	2	3	3

Appendix 1 - cont.

Species Compos. 0 = absent, 1 = rare, 2 = <1 %cover, 3 = 1 - 5% Cover, 4 = 5 - 50% cover, 5 = >50% cover

FAMILY	TAXON	LGCONV11	LGCONV12	LGCONV13	LGCONV14	OGCONV11	OGCONV12	OGCONV13	OGCONV14
Orchidaceae									
	Caladenia flava	0	0	0	3	1	0	0	0
	Caladenia reptans	1	1	2	2	2	2	2	1
	Pterostylis barbata	0	0	0	0	0	0	0	0
	Pterostylis ?nana	0	0	0	0	0	2	0	0
	Pterostylis vittata	0	1	0	0	0	0	0	0
	Thelymitra crinita	1	1	1	1	1	1	3	1
Oxalidaceae	* *Oxalis corniculata*	1	2	0	1	1	1	2	0
Pittosporaceae									
	Pronaya fraseri	0	0	0	0	0	0	0	0
Poaceae									
	Briza maxima	0	0	0	0	0	0	0	0
	Briza minor	0	0	0	0	0	0	1	0
	Neurachne alopecuroidea	2	2	1	2	2	1	2	2
	Hairy grass	2	1	2	1	1	1	2	1
Primulaceae									
	* *Anagallis arvensis*	0	0	0	0	0	1	0	0
Proteaceae									
	Dryandra lindleyana	3	4	3	4	3	4	3	4
	Hakea lissocarpha	2	3	2	1	3	3	3	4
	Persoonia longifolia	0	0	0	0	0	0	0	0
Ranunculaceae									
	Clematis pubescens	0	0	1	0	1	0	3	0
	Ranunculus colonoratum	0	0	0	0	0	0	0	0
Rhamnaceae									
	Trymalium floribundum	0	1	0	0	0	0	0	0
	Trymalium ledifolium	2	3	3	3	0	0	1	0
Rubiaceae									
	Opercularia echinocephala	1	2	1	2	1	3	2	2
Rutaceae									
	Boronia fastigiata	0	0	0	1	3	0	0	0
Santalaceae									
	Leptomeria cunninghamii	1	0	1	0	0	0	0	0
Stylidiaceae									
	Stylidium amoenum	0	0	0	0	1	0	0	0
	Stylidium bulbiferum	0	0	0	0	0	0	1	0
	Stylidium calcaratum	2	1	2	3	3	2	?	1
	Stylidium ciliatum	0	0	0	0	0	0	0	0
Thymeleaceae									
	Pimelea preissii	1	0	0	0	1	0	0	1
Tremandraceae									
	Tetratheca hirsuita	0	0	0		0	0	0	0

Appendix 1 - cont.

Species Compos. 0 = absent, 1 = rare, 2 = <1 %cover, 3 = 1 - 5% Cover, 4 = 5 - 50% cover, 5 = >50% cover

FAMILY	TAXON	LGCONV11	LGCONV12	LGCONV13	LGCONV14	OGCONV11	OGCONV12	OGCONV13	OGCONV14
Xanthorrhoeaceae									
	Xanthorrhoea gracilis	1	0	1	3	1	1	0	1
	Xanthorrhoea preisii	3	4	3	1	3	3	3	4
Zamiaceae									
	Macrozamia riedlei	2	2	0	1	4	2	4	4
Unknown Taxa									
	Lily V-shaped leaf	0	0	0	0	0	0	0	0
	Small herb kidney leaf	0	0	0	0	0	0	0	0
	Fine grass	0	0	0	0	1	2	0	0
	Weedy rosette serrated leaflets	1	0	0	0	0	0	0	1
	Small hairy rush	1	0	0	0	0	0	0	0
	Small shrub lvs alternate	0	0	0	1	0	0	0	0
	Very small herb divaricate lvs	0	0	0	0	0	0	0	0

Appendix 1

Species Compos. 0 = absent, 1 = rare, 2 = <1 %cover, 3 = 1 - 5% Cover, 4 = 5 - 50% cover, 5 = >50% cover

FAMILY	TAXON	LGEDSN11	LDEDSN12	LGEDSN13	LGEDSN14	OGEDSN11	OGEDSN12	OGEDSN13	OGEDSN14
Amaranthaceae									
	Ptilotus manglesii	4	2	3	4	3	4	3	4
Anthericaceae									
	Borya sphaerocephala?	0	0	0	0	0	0	1	0
	Chamaescilla corymbosa	1	2	2	1	3	2	1	2
	Thysanotus patersonii	0	0	0	0	0	0	0	0
	Thysanotus sparteus	0	0	0	0	1	0	0	0
Apiaceae									
	Pentapeltis peltigera	1	0	0	0	2	0	0	2
	Platysaceae juncea	0	0	1	0	0	0	1	0
Asteraceae									
	Trichocline spathulata	1	0	1	1	0	1	0	1
	Asterac. white rolled petals	0	0	0	0	0	0	0	0
Casuarinaceae									
	Allocasuarina humilis	3	4	0	0	4	4	4	4
	Allocasuarina fraseriana	0	0	0	0	0	0	0	0
Colchicaceae									
	Burchardia umbellata	0	0	0	0	3	3	0	2
Cyperaceae									
	Lepidosperma pubisquameum?	3	2	0	2	2	1	0	2
	Lepidosperma tenue	3	3	3	3	3	2	2	2
Dasypogonceae									
	Lomandra 'small grey'	2	1	1	2	2	2	2	2
Dilleniaceae									
	Hibbertia commutata	2	1	2	1	1	1	0	2
	Hibbertia hypericoides	4	3	3	3	3	3	3	3
	Hibbertia pachyrhiza	2	2	2	2	3	2	2	3
Droseraceae									
	Drosera erythrorhiza	2	2	2	0	3	3	3	2
	Drosera glanduligera	2	1	2	3	0	0	0	0
	Drosera pallida	1	2	2	2	3	2	2	1
	Drosera scorpioides	0	0	0	0	2	3	4	3
	Drosera stolonifera	1	2	0	0	0	0	2	1
Epacridaceae									
	Astroloma ciliatum	0	0	0	1	1	1	0	0
	Astroloma pallidum	3	2	2	2	2	2	3	2
	Leucopogon capitellatus	3	4	3	2	3	3	2	3
	Leucopogon oxycedrus	1	0	1	0	1	1	0	0
	Leucopogon pulchellus	0	1	0	0	0	0	0	0
	Styphelia tenuiflora	3	3	3	2	2	2	1	2

Appendix 1 - cont.

Species Compos. 0 = absent, 1 = rare, 2 = <1 %cover, 3 = 1 - 5% Cover, 4 = 5 - 50% cover, 5 = >50% cover

FAMILY	*TAXON*	LGEDSN11	LDEDSN12	LGEDSN13	LGEDSN14	OGEDSN11	OGEDSN12	OGEDSN13	OGEDSN14
Fabaceae									
	Bossiaea ornata	4	3	3	2	3	1	2	3
	Daviesia decurrens	2	2	2	1	3	2	2	2
	Daviesia polyphylla	1	1	1	1	3	0	2	2
	Daviesia preissii	2	1	2	1	2	0	0	1
	Gompholobium knightidatum	2	2	1	2	3	2	2	2
	Gompholobium marginatum	0	0	0	0	0	0	0	1
	Gompholobium shuttleworthii	2	0	0	0	0	3	2	0
	Hovea chorizemifolia	2	0	1	1	2	1	1	1
	Kennedia coccinea	0	2	2	0	0	0	0	1
	Labichea punctata	2	1	1	0	2	1	1	0
	Mibelia spinulosa?	0	0	0	0	0	0	0	0
	Sphaerolobium medium	1	0	0	0	0	0	0	0
	Brachysema ? sp.1	0	0	0	0	1	0	0	0
	Fabaceae glaucous lvs 30x10	0	0	0	0	0	0	0	0
Goodeniaceae									
	Dampiera linearis	2	2	1	1	3	2	2	2
	Dampiera alata	0	0	0	0	0	0	0	1
	Lechenaultia biloba	2	1	1	1	2	1	1	2
	Scaevola calliptera	0	1	0	0	1	0	0	1
	Scaevola pilosa	0	0	0	0	0	0	0	1
Haemodoraceae									
	Conostylis caricina	3	2	3	1	2	1	2	2
	Conostylis 'long lobes'	2	3	2	2	2	0	1	1
	Conostylis sp.2 lvs 180x1mm, 0.2xC	0	0	0	0	0	0	0	0
	Haemodorum sp.1	2	2	1	0	2	2	1	2
Iridaceae									
	Patersonia babianoides	3	2	3	2	4	3	3	3
	Patersonia occidentalis	0	0	0	0	0	0	0	2
	Patersonia pygmaea	2	2	3	1	3	2	2	1
	Patersonia sp.1 (160x1mm)	0	0	0	1	0	0	0	0
Lamiaceae									
	Hemiandra pungens	2	3	2	0	2	1	0	2
Lauraceae									
	Cassytha racemosa	3	3	1	1	2	2	3	2
Mimosaceae									
	Acacia applanata?	0	0	0	0	1	0	0	0
	Acacia lasiocarpa	2	1	3	2	1	2	2	2
	Acacia sp. two pairs of bipinnate lvs	0	0	0	0	0	0	0	0
	Acacia sp.5 phyllode 150x4mm	0	0	0	0	0	0	0	0
Myrtaceae									
	Agonis linearifolia	0	0	0	0	0	0	0	0
	Astartea fascicularis	0	0	0	0	0	0	0	0

Appendix 1 - Cont.

Species Compos. 0 = absent, 1 = rare, 2 = <1 %cover, 3 = 1 - 5% Cover, 4 = 5 - 50% cover, 5 = >50% cover

FAMILY	*TAXON*	LGEDSN11	LDEDSN12	LGEDSN13	LGEDSN14	OGEDSN11	OGEDSN12	OGEDSN13	OGEDSN14
Myrtaceae (cont.)									
	Baeckia camphorosmae	0	0	0	0	0	0	2	0
	Calothamnus quadrifidus	0	0	0	3	0	0	0	0
	Corymbia calophylla	1	0	0	2	0	0	1	0
	Eucalyptus marginata	2	1	2	1	0	0	1	1
	Eutaxia ?diliwynoides	0	0	0	0	0	0	0	0
	Leptospermum erubescens	0	0	0	3	0	0	2	0
	Melaleuca sp. 3 grey needle leaves	0	0	0	0	2	0	0	0
	Mirbelia ?spinosa	0	0	0	0	0	0	0	0
	Myrtaceae spiral leaf arrangemnt	0	0	0	0	0	0	0	1
	Myrtaceae dense lvs 3x1	0	0	0	0	0	0	0	1
Orchidaceae									
	Pyrochis nigricans	2	2	2	2	2	1	1	0
	Caladenia flava	0	0	0	0	0	0	0	0
	Caladenia longicauda	0	0	0	0	0	0	0	0
	Caladenia reptans	0	0	0	0	0	0	1	0
	Diuris brumalis	0	0	0	0	0	0	0	0
	Drakaea gracilis?	0	0	0	0	0	3	2	0
	Eriochilus dilatatus?	1	0	2	0	2	2	1	1
	Pterostylis barbata	0	0	0	0	1	0	0	0
	Pterostylis nana ?	0	0	0	0	2	1	0	2
	Pterostylis recurva	0	0	0	0	0	0	0	1
	Pterostylis vittata	0	0	0	0	0	0	0	0
	Thelymitra crinita	2	3	3	0	3	1	3	3
	Orchid *Pterostylis?*	1	0	0	0	2	1	0	2
	Orchid single grass leaf (80x5)	0	0	0	0	0	2	2	0
	Orchid grass sheathing base *Diuris?*	0	0	0	0	0	1	2	0
Pittosporaceae									
	Pronaya fraseri	0	0	0	0	0	0	0	0
Poaceae									
	Neurachne alopecuroidea	0	0	0	0	0	0	0	1
Proteaceae									
	Banksia grandis	1	0	0	0	0	0	0	0
	Dryandra carduacea	3	4	0	2	3	5	0	3
	Dryandra lindleyiana	3	2	2	1	3	1	2	3
	Dryandra sessilis	0	0	4	4	0	2	1	0
	Grevillea synaphae	2	1	1	1	1	1	0	1
	Hakea cyclocarpa	2	1	3	0	3	2	0	1
	Hakea lissocarpha	2	2	3	2	2	1	2	2
	Hakea ruscifolia	2	2	0	2	1	0	0	0
	Isopogon dubious	0	0	0	0	0	0	0	0
	Isopogon spaerocephalus	0	0	0	0	0	0	1	1
	Isopogon teretefolius	0	1	0	2	1	1	0	2
	Petrophile biloba	0	0	0	0	0	0	1	1
	Petrophile seminuda	0	0	0	2	3	3	2	3

Appendix 1 - cont.

Species Compos. 0 = absent, 1 = rare, 2 = <1 %cover, 3 = 1 - 5% Cover, 4 = 5 - 50% cover, 5 = >50% cover

FAMILY	TAXON	LGEDSN11	LDEDSN12	LGEDSN13	LGEDSN14	OGEDSN11	OGEDSN12	OGEDSN13	OGEDSN14
	Petrophile striata	3	3	3	2	2	2	2	2
	Synaphea petiolaris?	0	0	1	0	0	0	0	0
Restionaceae									
	Spear Grass.leaves brn/rd	2	0	0	0	0	0	0	0
	Desmocladus fasciculatis	0	0	3	1	2	2	2	2
	Restionaceae hairy rush	2	1	1	1	2	2	1	1
	Restionaceae grey wiry twisty rush	3	3	2	3	3	2	3	1
	Restionaceae tall grey tufted rush	0	0	0	1	1	0	0	1
	Restionaceae fine twisted rush	0	0	0	0	0	2	2	0
Rubiaceae									
	Opercularia echinocephala	0	0	0	0	0	0	1	0
Santalaceae									
	Leptomeria cunninghamii	0	0	0	0	0	0	1	0
	Santalaceae?	0	0	0	0	1	0	0	0
Stackhousiaceae									
	Tripterococcus brunonis	0	1	0	0	0	0	0	0
Sterculiaceae									
	Sterculiaceae sp lobed leaves	0	0	0	0	0	0	0	0
Stylidiaceae									
	Stylidium amoenum	3	1	1	3	4	0	0	4
	Stylidium brunonianum	3	3	3	3	3	4	3	4
	Stylidium ciliatum	2	0	2	0	1	1	2	2
	Stylidium junceum	0	0	0	2	3	2	3	3
	Stylidium shoenoides	0	0	0	0	1	1	0	0
	Stylidium small tuft 15x1 thread tip	0	0	0	0	0	0	1	0
	Stylidium adventit. roots lvs 6x0.5 te	0	0	0	0	0	0	0	0
Thymeleaceae									
	Pimelea preissii	0	0	0	0	0	0	0	0
Tremandraceae									
	Tetratheca hirsuita	2	0	0	0	0	1	1	3
Xanthorrhoeaceae									
	Xanthorrhoea gracilis	0	0	0	0	0	0	0	0
Unknown Taxa									
	Small herb divaricate leaves	1	1	1	1	1	1	0	2
	appressed lvs Olax benthamiana?	1	1	0	0	0	0	0	0
	herb basal crenate lvs 60x20mm	1	0	1	1	0	0	0	1
	Asteraceae - flatweed?	0	0	1	0	0	0	0	0
	Herb divaricate lvs compound umbe	0	0	0	0	0	0	0	0
	Tufted lush grass lvs 400x5mm	0	0	0	0	0	0	0	0

Appendix 1

Species Compos. 0 = absent, 1 = rare, 2 = <1 %cover, 3 = 1 - 5% Cover, 4 = 5 - 50% cover, 5 = >50% cover

FAMILY	TAXON	LGEDSN21	LGEDSN22	LGEDSN23	LGEDSN24	OGEDSN21	OGEDSN22	OGEDSN23	OGEDSN24
Amaranthaceae									
	Ptilotus manglesii	3	4	4	3	4	4	3	4
Anthericaceae									
	Borya sphaerocephala?	0	0	0	0	0	0	0	0
	Chamaescilla corymbosa	1	3	1	2	3	2	2	2
	Thysanotus patersonii	1	1	0	2	1	0	0	0
	Thysanotus sparteus	0	0	0	0	0	0	0	0
Apiaceae									
	Pentapeltis peltigera	0	0	0	0	0	1	0	0
	Platysaceae juncea	0	0	0	0	0	0	1	0
Asteraceae									
	Trichocline spathulata	3	3	1	1	1	0	2	0
	Asterac. white rolled petals	1	0	1	0	0	0	0	0
Casuarinaceae									
	Allocasuarina humilis	0	0	0	0	1	0	3	4
	Allocasuarina fraseriana	1	0	0	0	0	0	0	0
Colchicaceae									
	Burchardia umbellata	3	3	0	2	0	2	1	0
Cyperaceae									
	Lepidosperma pubisquameum?	0	2	0	0	3	2	3	3
	Lepidosperma tenue	4	3	3	4	2	3	2	2
Dasypogonceae									
	Lomandra 'small grey'	2	1	1	1	2	2	2	1
Dillenaceae									
	Hibbertia commutata	3	2	1	2	2	1	2	1
	Hibbertia hypericoides	2	3	3	3	4	4	4	3
	Hibbertia pachyrhiza	3	2	2	3	2	2	2	2
Droseraceae									
	Drosera erythrorhiza	3	2	3	2	3	2	3	3
	Drosera glanduligera	4	4	4	2	0	0	0	0
	Drosera pallida	1	2	3	2	2	2	3	3
	Drosera scorpioides	0	0	0	0	3	3	3	4
	Drosera stolonifera	1	2	2	0	0	1	1	0
Epacridaceae									
	Astroloma ciliatum	0	0	0	0	2	0	1	2
	Astroloma pallidum	2	3	3	3	2	2	1	3
	Leucopogon capitellatus	1	1	3	0	3	3	3	3
	Leucopogon oxycedrus	3	0	2	0	2	1	0	1
	Leucopogon pulchellus	0	0	0	0	0	0	0	0
	Styphelia tenuiflora	1	1	2	2	3	2	1	2

Appendix 1 - cont.

Species Compos. 0 = absent, 1 = rare, 2 = <1 %cover, 3 = 1 - 5% Cover, 4 = 5 - 50% cover, 5 = >50% cover

FAMILY	TAXON								
Fabaceae									
	Bossiaea ornata	3	2	3	3	2	2	3	3
	Daviesia decurrens	3	2	2	3	3	3	3	3
	Daviesia polyphylla	2	2	2	2	2	2	3	1
	Daviesia preissii	2	2	1	1	1	0	0	0
	Gompholobium knightidatum	1	1	2	1	2	2	2	2
	Gompholobium marginatum	0	0	0	0	0	0	0	0
	Gompholobium shuttleworthii	2	1	0	2	0	1	0	0
	Hovea chorizemifolia	0	2	2	2	2	2	1	1
	Kennedia coccinea	1	1	0	0	0	1	0	0
	Labichea punctata	0	1	1	1	2	2	1	1
	Mibelia spinulosa?	0	0	0	2	0	0	0	0
	Sphaerolobium medium	0	0	0	0	0	0	0	0
	Brachysema ? sp.1	0	0	0	0	0	0	0	0
	Fabaceae glaucous lvs 30x10	1	1	1	0	0	1	0	0
Goodeniaceae									
	Dampiera linearis	2	2	2	2	3	1	1	1
	Dampiera alata	1	0	1	1	1	1	0	0
	Lechenaultia biloba	2	2	2	2	2	2	1	1
	Scaevola calliptera	1	2	1	1	2	0	1	1
	Scaevola pilosa	0	0	0	0	0	0	0	0
Haemodoraceae									
	Conostylis caricina	3	1	1	1	2	3	3	3
	Conostylis 'long lobes'	1	0	1	0	0	0	1	0
	Conostylis sp.2 lvs 180x1mm, 0.2	0	1	0	0	0	1	0	1
	Haemodorum sp.1	0	0	2	0	3	2	2	2
Iridaceae									
	Patersonia babianoides	0	0	0	0	3	1	3	3
	Patersonia occidentalis	3	3	2	3	3	3	3	3
	Patersonia pygmaea	1	0	0	0	0	0	0	0
	Patersonia sp.1 (160x1mm)	0	0	1	0	0	0	0	0
Lamiaceae									
	Hemiandra pungens	1	2	0	1	1	1	2	1
Lauraceae									
	Cassytha racemosa	2	1	2	2	1	0	0	0
Mimosaceae									
	Acacia applanata?	1	1	2	1	0	1	0	0
	Acacia lasiocarpa	2	2	2	2	3	2	2	2
	Acacia sp. two pairs of bipinnate l	0	0	0	1	0	1	0	0
	Acacia sp.5 phyllode 150x4mm	0	0	0	0	0	0	0	0
Myrtaceae									
	Agonis linearifolia	0	0	0	0	0	0	0	0

Appendix 1

Species Compos. 0 = absent, 1 = rare, 2 = <1 %cover, 3 = 1 - 5% Cover, 4 = 5 - 50% cover, 5 = >50% cover

FAMILY	*TAXON*	LGEDSN11	LDEDSN12	LGEDSN13	LGEDSN14	OGEDSN11	OGEDSN12	OGEDSN13	OGEDSN14
	Astartea fascicularis	0	0	0	0	0	0	0	0
	Baeckia camphorosmae	1	0	2	0	0	2	0	0
	Calothamnus quadrifidus	0	0	4	0	0	2	0	3
	Corymbia calophylla	3	1	1	1	0	2	1	2
	Eucalyptus marginata	1	2	3	3	2	1	0	2
	Eutaxia ?dillwynoides	0	0	1	0	0	0	0	0
	Leptospermum erubescens	0	0	4	0	0	0	0	0
	Melaleuca sp. 3 grey needle leave	0	0	0	0	0	0	0	0
	Mirbelia ?spinosa	0	0	0	2	0	0	0	0
	Myrtaceae spiral leaf arrangemnt	2	0	0	0	0	1	0	0
	Myrtaceae dense lvs 3x1	0	0	0	0	0	0	0	0
Orchidaceae									
	Pyrochis nigricans	0	0	0	0	0	3	2	0
	Caladenia flava	0	0	0	0	0	0	0	0
	Caladenia longicauda	0	0	1	0	1	1	2	2
	Caladenia reptans	1	0	0	1	0	1	2	1
	Diuris brumalis	1	1	1	0	2	1	2	0
	Drakaea gracilis?	1	0	3	0	2	2	2	2
	Eriochilus dilatatus?	0	2	0	0	1	2	1	3
	Pterostylis barbata	0	1	0	0	0	0	0	0
	Pterostylis nana ?	2	2	2	1	1	1	2	2
	Pterostylis recurva	1	0	0	0	0	0	0	0
	Pterostylis vittata	0	0	0	0	0	0	2	1
	Thelymitra crinita	2	2	2	1	0	1	0	3
	Orchid *Pterostylis?*	1	1	2	1	1	0	1	0
	Orchid single grass leaf (80x5)	0	0	0	0	0	1	1	3
	Orchid grass sheathing base *Diuri*	1	0	0	0	0	1	1	0
Pittosporaceae									
	Pronaya fraseri	0	0	0	0	0	0	0	1
Poaceae									
	Neurachne alopecuroidea	3	2	2	2	2	1	1	2
Proteaceae									
	Banksia grandis	0	0	0	0	0	0	3	2
	Dryandra carduacea	2	0	0	0	5	3	4	5
	Dryandra lindleyana	3	2	2	2	1	3	2	0
	Dryandra sessilis	2	0	0	2	0	4	3	1
	Grevillea synaphae	2	3	2	1	0	1	2	1
	Hakea cyclocarpa	1	3	2	3	3	1	1	2
	Hakea lissocarpha	2	2	0	2	2	2	0	0
	Hakea ruscifolia	0	0	3	0	0	2	3	0
	Isopogon dubious	3	2	1	0	2	2	0	0
	Isopogon spaerocephalus	0	0	0	0	0	0	0	0
	Isopogon teretefolius	2	0	2	1	2	2	1	2
	Petrophile biloba	0	0	0	0	0	0	0	0
	Petrophile seminuda	0	0	0	0	0	0	0	0

Appendix 1 - cont.

Species Compos. 0 = absent, 1 = rare, 2 = <1 %cover, 3 = 1 - 5% Cover, 4 = 5 - 50% cover, 5 = >50% cover

FAMILY	TAXON	LGEDSN21	LGEDSN22	LGEDSN23	LGEDSN24	OGEDSN21	OGEDSN22	OGEDSN23	OGEDSN24
	Petrophile striata	2	2	1	2	2	2	2	2
	Synaphea petiolaris?	0	0	0	0	2	0	2	2
Restionaceae									
	Spear Grass.leaves brn/rd	0	0	1	1	1	0	0	0
	Desmocladus fasciculatis	1	0	1	2	1	0	2	3
	Restionaceae hairy rush	1	1	2	2	2	2	1	0
	Restionaceae grey wiry twisty rush	3	3	2	3	3	2	3	0
	Restionaceae tall grey tufted rush	0	0	0	1	2	1	0	1
	Restionaceae fine twisted rush	0	0	0	0	0	0	0	0
Rubiaceae									
	Opercularia echinocephala	0	0	1	0	1	1	1	0
Santalaceae									
	Leptomeria cunninghamii	0	3	0	0	2	1	2	1
	Santalaceae?	0	0	0	0	0	0	0	0
Stackhousiaceae									
	Tripterococcus brunonis	0	0	0	0	0	0	0	0
Sterculiaceae									
	Sterculiaceae sp lobed leaves	0	1	1	0	2	0	0	2
Stylidiaceae									
	Stylidium amoenum	3	3	2	0	4	3	3	3
	Stylidium brunonianum	0	1	2	1	3	3	4	2
	Stylidium ciliatum	0	0	1	1	2	0	3	3
	Stylidium junceum	3	4	4	0	3	3	3	3
	Stylidium shoenoides	0	0	0	0	0	2	0	0
	Stylidium small tuft 15x1 thread tip	0	1	0	0	2	0	0	0
	Stylidium adventit. roots lvs 6x0.5	0	1	0	0	0	0	0	0
Thymeleaceae									
	Pimelea preissii	0	0	1	1	0	0	0	0
Tremandraceae									
	Tetratheca hirsuita	1	2	1	0	2	1	1	1
Xanthorrhoeaceae									
	Xanthorrhoea gracilis	2	0	0	0	0	0	0	0
Unknown Taxa									
	Small herb divaricate leaves	2	0	1	0	1	1	2	1
	appressed lvs Olax benthamiana?	1	1	0	0	1	0	0	0
	herb basal crenate lvs 60x20mm	2	1	1	1	1	0	1	0
	Asteraceae - flatweed?	0	0	0	0	0	0	0	0
	Herb divaricate lvs compound umt	0	0	0	0	0	0	0	0
	Tufted lush grass lvs 400x5mm	2	2	2	2	1	1	0	0

Appendix 2 - Cryptophyte Counts

Taxon	lgedsn11	lgedsn12	lgedsn13	lgedsn14
Anthericaceae sp.1	0	0	0	0
Burchardia umbellata	0	0	0	0
Caladenia flava	0	0	0	0
Caladenia longicauda	0	0	0	0
Caladenia reptans	2	0	5	4
Chamaescilla corymbosa	12	9	11	22
Clematis pubescens	0	0	0	0
Craspedia variablis	0	0	0	0
Diuris brumalis	0	0	0	0
Drakaea ?gracilis	21	7	67	0
Drosera erythrorhiza	31	18	8	0
Drosera glanduligera	0	0	0	0
Drosera pallida	1	2	11	1
Drosera scorpiodes	0	0	0	0
Drosera stolonifera	56	7	18	64
Eriochilus dilatatus	4	0	0	0
Haemodorum strap leaf	17	60	24	1
Herb divaric yellow flwrs	0	0	0	0
Herb Kidney leaf	0	0	0	0
Lagenophera huegellii	0	0	12	0
Lush grass soft	0	0	0	0
Myriophyllum asparagoides	0	0	0	0
Orchid single leaf 80x10mm	0	0	0	0
Oxalis stolonifera	0	0	0	0
Patersonia babiodes purple flag	35	10	42	11
Pterostylis barbata	0	0	0	0
Pterostylis ? nana	4	0	0	0
Pterostylis recurva	0	0	0	0
Pterostylis vittata	0	0	0	0
Ptilotus manglesii	113	41	74	151
Pyrochis nigricans	11	5	25	11
Stylidium amoenum	14	1	1	0
Stylidium brunonianum	126	216	67	13
Stylidium bulbiferum	0	0	0	0
Stylidium ciliatum	8	6	4	19
Stylidium junceum	0	0	0	3
Stylidium shoenoides	0	0	0	0
Thelymitra crinata	0	0	0	0
Thelymitra pauciflora	0	0	0	0
Thysanotus climbing	0	0	0	0
Thysanotus white	0	0	0	0
Trichocline spathulata	6	0	9	5
Hypochaeris glabra	0	0	0	0
Total	461	382	378	305

Appendix 2 - Cryptophyte Counts (cont.)

Taxon	ogedsn11	ogedsn12	ogedsn13	ogedsn14
Anthericaceae sp.1	0	0	0	0
Burchardia umbellata	0	0	0	0
Caladenia flava	11	7	12	7
Caladenia longicauda	0	0	0	0
Caladenia reptans	7	13	3	39
Chamaescilla corymbosa	11	36	60	22
Clematis pubescens	0	0	0	0
Craspedia variablis	0	0	0	0
Diuris brumalis	0	0	0	0
Drakaea ?gracilis	0	267	77	7
Drosera erythrorhiza	35	49	40	15
Drosera glanduligera	0	0	0	0
Drosera pallida	11	9	8	8
Drosera scorpiodes	2	16	80	30
Drosera stolonifera	0	0	5	1
Eriochilus dilatatus	14	7	9	4
Haemodorum strap leaf	85	16	35	57
Herb divaric yellow flwrs	0	0	0	0
Herb Kidney leaf	0	0	0	0
Lagenophera huegellii	0	0	2	1
Lush grass soft	0	0	0	0
Myriophyllum asparagoides	0	0	0	0
Orchid single leaf 80x10mm	0	0	0	0
Oxalis stolonifera	0	0	0	0
Patersonia babiodes purple flag	96	26	30	46
Pterostylis barbata	1	0	0	0
Pterostylis ? nana	8	3	1	2
Pterostylis recurva	1	0	0	0
Pterostylis vittata	1	0	3	1
Ptilotus manglesii	43	76	46	98
Pyrochis nigricans	0	0	0	0
Stylidium amoenum	75	0	0	78
Stylidium brunonianum	42	86	37	97
Stylidium bulbiferum	0	0	0	0
Stylidium ciliatum	8	30	44	17
Stylidium junceum	19	2	12	37
Stylidium shoenoides	1	1	0	0
Thelymitra crinata	6	1	17	8
Thelymitra pauciflora	0	0	0	0
Thysanotus climbing	0	0	0	0
Thysanotus white	0	0	0	0
Trichocline spathulata	0	2	1	0
Hypochaeris glabra	0	0	0	0
Total	477	647	522	575

Appendix 2 - Cryptophyte Counts (cont.)

taxon	lgedsn21	lgedsn22	lgedsn23	lgedsn24
Anthericaceae sp.1	0	0	0	0
Burchardia umbellata	11	12	0	3
Caladenia flava	2	0	3	2
Caladenia longicauda	0	0	1	0
Caladenia reptans	1	12	0	13
Chamaescilla corymbosa	40	46	30	50
Clematis pubescens	0	0	0	0
Craspedia variablis	0	0	0	0
Diuris brumalis	0	4	0	0
Drakaea ?gracilis	0	0	113	0
Drosera erythrorhiza	25	18	50	13
Drosera glanduligera	182	71	196	0
Drosera pallida	0	13	37	23
Drosera scorpiodes	0	0	0	0
Drosera stolonifera	0	0	0	0
Eriochilus dilatatus	0	6	0	0
Haemodorum strap leaf	0	1	63	0
Herb divaric yellow flwrs	0	0	0	0
Herb Kidney leaf	0	0	0	0
Lagenophera huegellii	1	0	0	0
Lush grass soft	0	0	0	0
Myriophyllum asparagoides	0	0	0	0
Orchid single leaf 80x10mm	0	0	0	0
Oxalis stolonifera	0	0	0	0
Patersonia babiodes purple flag	0	0	0	0
Pterostylis barbata	0	1	0	0
Pterostylis ? nana	7	3	1	1
Pterostylis recurva	0	9	4	8
Pterostylis vittata	4	0	0	0
Ptilotus manglesii	48	50	64	36
Pyrochis nigricans	0	0	0	0
Stylidium amoenum	8	27	0	0
Stylidium brunonianum	0	0	7	0
Stylidium bulbiferum	0	0	0	0
Stylidium ciliatum	2	2	1	0
Stylidium junceum	36	125	4	17
Stylidium shoenoides	0	1	0	2
Thelymitra crinata	2	2	2	1
Thelymitra pauciflora	0	0	0	0
Thysanotus climbing	0	0	0	0
Thysanotus white	0	0	0	0
Trichocline spathulata	24	15	4	21
Hypochaeris glabra	0	0	0	0
Total	393	418	580	190

Appendix 2 - Cryptophyte Counts (cont.)

Taxon	ogedsn21	ogedsn22	ogedsn23	ogedsn24
Anthericaceae sp.1	0	0	0	0
Burchardia umbellata	0	2	1	0
Caladenia flava	1	9	2	9
Caladenia longicauda	0	0	0	0
Caladenia reptans	9	4	9	179
Chamaescilla corymbosa	47	38	41	37
Clematis pubescens	0	0	0	0
Craspedia variablis	0	0	0	0
Diuris brumalis	1	2	1	0
Drakaea ?gracilis	19	41	17	0
Drosera erythrorhiza	54	85	98	76
Drosera glanduligera	0	0	0	0
Drosera pallida	35	10	16	18
Drosera scorpiodes	5	49	42	56
Drosera stolonifera	1	0	0	0
Eriochilus dilatatus	7	4	6	27
Haemodorum strap leaf	68	85	18	11
Herb divaric yellow flwrs	0	0	0	0
Herb Kidney leaf	0	0	0	0
Lagenophera huegellii	0	1	0	0
Lush grass soft	0	0	0	0
Myriophyllum asparagoides	0	0	0	0
Orchid single leaf 80x10mm	0	0	0	0
Oxalis stolonifera	0	0	0	0
Patersonia babiodes purple flag	9	1	12	15
Pterostylis barbata	0	0	0	0
Pterostylis ? nana	3	5	0	4
Pterostylis recurva	1	5	5	3
Pterostylis vittata	0	0	3	0
Ptilotus manglesii	65	108	48	78
Pyrochis nigricans	0	108	3	0
Stylidium amoenum	54	48	32	34
Stylidium brunonianum	1	38	65	4
Stylidium bulbiferum	0	0	0	0
Stylidium ciliatum	7	6	72	56
Stylidium junceum	34	30	10	6
Stylidium shoenoides	0	2	0	0
Thelymitra crinata	0	1	0	8
Thelymitra pauciflora	0	0	0	0
Thysanotus climbing	0	0	0	0
Thysanotus white	0	0	0	0
Trichocline spathulata	1	0	2	27
Hypochaeris glabra	0	0	0	0
Total	422	682	503	648

Appendix 2 - Cryptophyte Counts (cont.)

Taxon	lgcann11	lgcann12	lgcann13	lgcann14
Anthericaceae sp.1	0	0	0	0
Burchardia umbellata	5	1	3	3
Caladenia flava	0	0	1	1
Caladenia longicauda	0	0	0	0
Caladenia reptans	0	1	1	3
Chamaescilla corymbosa	0	0	0	0
Clematis pubescens	5	0	0	1
Craspedia variablis	0	0	0	0
Diuris brumalis	0	0	0	0
Drakaea ?gracilis	0	0	0	0
Drosera erythrorhiza	0	0	0	0
Drosera glanduligera	0	0	0	0
Drosera pallida	0	0	1	1
Drosera scorpiodes	0	0	0	0
Drosera stolonifera	0	0	0	0
Eriochilus dilatatus	0	0	1	0
Haemodorum strap leaf	0	0	0	0
Herb divaric yellow flwrs	0	0	0	0
Herb Kidney leaf	0	0	0	0
Lagenophera huegellii	37	31	30	53
Lush grass soft	3	0	0	3
Myriophyllum asparagoides	0	0	0	0
Orchid single leaf 80x10mm	0	0	0	0
Oxalis stolonifera	1	18	0	0
Patersonia babiodes purple fl	0	0	3	2
Pterostylis barbata	2	0	0	0
Pterostylis ? nana	0	0	0	0
Pterostylis recurva	0	0	0	0
Pterostylis vittata	0	0	0	0
Ptilotus manglesii	0	0	0	0
Pyrochis nigricans	0	0	0	0
Stylidium amoenum	3	0	5	4
Stylidium brunonianum	0	0	0	0
Stylidium bulbiferum	18	23	2	0
Stylidium ciliatum	0	3	12	13
Stylidium junceum	0	0	0	0
Stylidium shoenoides	0	0	0	0
Thelymitra crinata	0	0	0	1
Thelymitra pauciflora	0	0	0	0
Thysanotus climbing	0	0	0	0
Thysanotus white	0	0	0	0
Trichocline spathulata	0	0	0	0
Hypochaeris glabra	0	0	0	0
Total	74	77	59	85

Appendix 2 - Cryptophyte Counts (cont.)

Taxon	ogcann11	ogcann12	ogcann13	ogcann14
Anthericaceae sp.1	0	0	0	0
Burchardia umbellata	1	0	1	3
Caladenia flava	0	0	0	0
Caladenia longicauda	0	0	0	0
Caladenia reptans	0	0	0	1
Chamaescilla corymbosa	0	0	0	1
Clematis pubescens	142	168	152	170
Craspedia variablis	0	0	0	0
Diuris brumalis	0	0	0	0
Drakaea ?gracilis	0	0	0	0
Drosera erythrorhiza	0	0	0	0
Drosera glanduligera	0	0	0	0
Drosera pallida	0	0	0	0
Drosera scorpiodes	0	0	0	0
Drosera stolonifera	0	0	0	0
Eriochilus dilatatus	0	0	0	0
Haemodorum strap leaf	0	0	0	0
Herb divaric yellow flwrs	86	34	7	20
Herb Kidney leaf	5	0	0	0
Lagenophera huegellii	93	44	15	16
Lush grass soft	6	0	0	3
Myriophyllum asparagoides	1	1	0	0
Orchid single leaf 80x10mm	0	0	0	0
Oxalis stolonifera	55	0	3	25
Patersonia babiodes purple flag	0	0	0	0
Pterostylis barbata	0	0	0	0
Pterostylis ? nana	0	0	0	0
Pterostylis recurva	0	0	0	0
Pterostylis vittata	0	0	0	0
Ptilotus manglesii	0	0	0	0
Pyrochis nigricans	0	0	0	0
Stylidium amoenum	0	0	0	0
Stylidium brunonianum	0	0	0	0
Stylidium bulbiferum	7	0	21	4
Stylidium ciliatum	0	0	0	0
Stylidium junceum	0	0	0	0
Stylidium shoenoides	0	0	0	0
Thelymitra crinata	0	0	0	0
Thelymitra pauciflora	0	0	1	0
Thysanotus climbing	0	0	0	1
Thysanotus white	0	0	0	1
Trichocline spathulata	0	0	0	0
Hypochaeris glabra	0	0	0	0
Total	396	247	200	245

Appendix 2 - Cryptophyte Counts (cont.)

Taxon	lgconv11	lgcconv12	lgconv13	lgconv14
Anthericaceae sp.1	0	0	0	0
Burchardia umbellata	31	13	9	5
Caladenia flava	0	0	0	10
Caladenia longicauda	0	0	0	0
Caladenia reptans	5	4	5	5
Chamaescilla corymbosa	111	207	135	23
Clematis pubescens	0	0	0	0
Craspedia variablis	108	116	113	142
Diuris brumalis	0	0	0	0
Drakaea ?gracilis	0	0	0	0
Drosera erythrorhiza	109	62	56	57
Drosera glanduligera	0	0	0	0
Drosera pallida	2	1	0	0
Drosera scorpiodes	0	0	0	0
Drosera stolonifera	15	0	26	2
Eriochilus dilatatus	0	0	0	0
Haemodorum strap leaf	0	0	0	2
Herb divaric yellow flwrs	0	0	0	0
Herb Kidney leaf	0	0	0	0
Lagenophera huegellii	5	14	7	8
Lush grass soft	0	0	0	0
Myriophyllum asparagoides	0	0	0	0
Orchid single leaf 80x10mm	0	0	0	0
Oxalis stolonifera	0	0	0	0
Patersonia babiodes purple flag	0	0	0	0
Pterostylis barbata	0	0	0	0
Pterostylis ? nana	0	1	0	0
Pterostylis recurva	0	0	0	0
Pterostylis vittata	0	0	0	0
Ptilotus manglesii	0	0	0	0
Pyrochis nigricans	0	0	0	0
Stylidium amoenum	0	0	0	0
Stylidium brunonianum	0	0	0	0
Stylidium bulbiferum	0	0	0	0
Stylidium ciliatum	0	0	0	0
Stylidium junceum	0	0	0	0
Stylidium shoenoides	0	0	0	0
Thelymitra crinata	1	0	2	2
Thelymitra pauciflora	0	0	0	0
Thysanotus climbing	0	0	0	0
Thysanotus white	0	0	0	0
Trichocline spathulata	9	16	28	25
Hypochaeris glabra	0	0	0	0
Total	396	434	381	281

Appendix 2 - Cryptophyte Counts (cont.)

Taxon	ogconv11	ogconv12	ogconv13	ogconv14
Anthericaceae sp.1	0	0	1	3
Burchardia umbellata	13	0	0	0
Caladenia flava	0	23	1	6
Caladenia longicauda	0	0	0	0
Caladenia reptans	38	20	1	23
Chamaescilla corymbosa	40	56	62	74
Clematis pubescens	0	0	1	1
Craspedia variablis	10	56	6	1
Diuris brumalis	0	0	0	0
Drakaea ?gracilis	0	0	0	0
Drosera erythrorhiza	35	6	20	18
Drosera glanduligera	0	0	0	0
Drosera pallida	0	0	0	0
Drosera scorpiodes	0	0	0	0
Drosera stolonifera	0	0	0	0
Eriochilus dilatatus	0	0	0	0
Haemodorum strap leaf	0	4	0	4
Herb divaric yellow flwrs	0	0	0	0
Herb Kidney leaf	0	0	0	0
Lagenophera huegellii	12	5	24	25
Lush grass soft	0	0	0	0
Myriophyllum asparagoides	0	0	0	0
Orchid single leaf 80x10mm	0	0	0	0
Oxalis stolonifera	0	6	3	0
Patersonia babiodes purple flag	0	0	0	0
Pterostylis barbata	0	0	0	0
Pterostylis ? nana	0	4	0	0
Pterostylis recurva	0	0	0	0
Pterostylis vittata	0	0	0	0
Ptilotus manglesii	0	0	0	0
Pyrochis nigricans	0	0	0	0
Stylidium amoenum	0	1	0	0
Stylidium brunonianum	0	0	0	0
Stylidium bulbiferum	0	0	0	0
Stylidium ciliatum	0	0	0	0
Stylidium junceum	0	0	0	0
Stylidium shoenoides	0	0	0	0
Thelymitra crinata	0	2	21	2
Thelymitra pauciflora	0	0	0	0
Thysanotus climbing	0	0	0	1
Thysanotus white	0	0	0	0
Trichocline spathulata	3	0	0	2
Hypochaeris glabra	0	1	1	2
Total	151	184	141	162